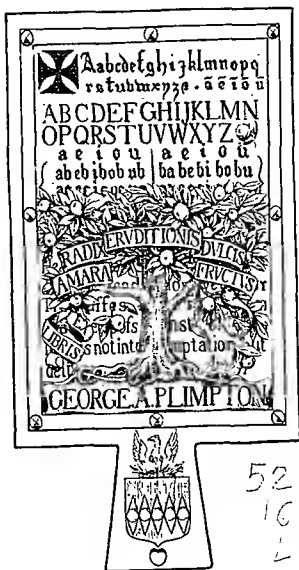


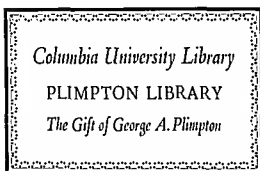
126 Leybourn (William) *THE COMPLEAT SURVEYOR*, Containing the whole Art of Surveying Land. By the Plaine Table, Theodolite, Circumferentor, Peractor, and other instruments. Small folio, engraved frontispiece of the author at 30 years of age, numerous woodcut diagrams and crude illustrations, autograph of Tho. Bainbrigg on title, contemporary calf. £3 10 0

R. and W. Leybourne: London 1657

Not in Lowndes, who notes "Wm. Leyhourn published many other scientific works, all of which are esteemed." The fifth edition appeared in 1722, edited by Samuel Gunn, who says in the preface, "The author of this treatise was frequently employed in surveying, measuring, and mapping gentlemen's estates, as evidently appears from the several draughts by him drawn and to be met with in almost every county in England." D.N.B. XI, 1087 remarks that the author "is said to have begun life as a printer," and it will be noticed that this volume was printed by R. & W. Leyhourn. The D.N.B. says his works are "clear and attractive in style."



526.9
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*Vera Effigies Guielmi Leybourn,
Philom. anno Etatis. 30.*

The Bainbrigg y^e 4 April 1700
his book

THE COMPLEAT SURVEYOR,

*Containing the whole ART of
Surveying of Land*

BY THE

Author of the *Plains, and other Instruments*

With a more easie, exact and compendious
manner, then hath been hitherto published by any : the *Plain Table* being
so contrived, that it alone will conveniently perform whatsoever may be done by
any of the fore-mentioned *Instruments*, or any other yet invented,
with the same ease and exactness ; and in many
cases much better.

Together with the taking of all manner of
Heights and Distances, either accessible or in-accessible, the Plotting and
Protracting of all manner of Grounds, either small Inclosures, Champion Plains,
Wood-lands, or any other Mountainous and un-even grounds, Also, how
to take the Plot of a whole Manor, to cast up the content, and to
make a perfect Chart or Map thereof. All which parti-
culars are performed three several ways, and
and by three several *Instruments*.

Hereunto is added a new way of *Surveying of Land*
by which a man may be satisfied whether his Plot will close before he
begins to protract the same, with the manner how to order such Water Colours as are
necessary for the beautifying of *Maps and Plans* ; Also how to know whether
Water may be convey'd from a Spring-head to any appointed place or
not, and how to effect the same : With whatsoever else is
necessary to the *Art of Surveying*.

The Second Edition, with many Additions.

By WILLIAM LEECHES

L O N D O N,

Printed by and for *at the signe of*
the Bible upon *Ludg-gate-hill, M. DC. LVII.*



TO HIS MUCH
HONOURD FRIEND

EDMUND WINGATE,
of *Graves Inn* Esq.

SIR,



His *Treatise* being finished, and ready to see the light, I could not bethink my selfe of a fitter Patron then your self to protect it; Your knowledge in, and affection to the Sciences *Mathematical*, as also the civil respect you usually vouchsafe such as affect those Studies, arm me with this confidence.

I foresee that this my presumption in exposing this Work to publike view, may meet with some *Detractions*, but Your approbation thereof, will both convince them of their *Erreur*, and plentifully satisfie

The Epistle Dedicatory.

Excuse me for the pains I have taken therein. Howbeit, what reception soever it may obtain with the *Vulgar*, my intention (I doubt not) will give me support and encouragement, my aime therein being nothing else but the publike good, and this my Dedication an evidence to let You know how much I am,

SIR,

*Your most humble and
obliged Servant,*

William Leybourn.



TO THE READER.

Courteous Reader,



About three yeares since there came into the World a little Pamphlet entituled *Plasometria*, or the whole Art of Surveying of Land, under the name of *Clicer Wallinby*, of which I confests my self to be the Authour, that name being only the true letters of my own name transposed. I was, indeed very unwilling the World should know me to be the Author thereof, it being so immaterial a Treatise, and too particular for a Subject of so large an extent, but that was occasioned by over-much haste, for (being urged thereunto) it was not above six weeks conceived before it was brought forth, and therefore must needs be little less then monstrous: yet the good acceptance which that Pamphlet received, occasioned me to prosecute that Subject more at large.

Now as the opinions of men in the World are various, so I know this Work will be variously censured, and therefore it might (perchance) be expected by some, that I should make an apologie for my self, as to crave pardon or excuse for whatsoever any man shall be pleased to object against, but I mean to make no excuse, for I know of nothing that needs it, neither did I ever know any Book the more favoured for the Authours bespeaking it; besides, the subject of the ensuing Treatise being *Geometry*, needeth no such thing, for [*Demonstration*] the grand supporter thereof, is able to withstand all opposers, and silently with Lines and Figures to *non-plus* the most malevolent tongue or Pen that shall either speak or write against it. But to the judicious Reader I shall say thus much; As I dare not think my doings free from all exception, so I do not know of any thing herein contained worthily deserving blame: Some small oversights which may possibly have crept in by chance, I must intreat the friendly Reader to over-see or wink at, as for the

To the Reader.

understanding Reader, I am sure he will scorn to cavil at every slight mistake or literal fault in the Printing: as for material faults I know of none in the whole Work, although I have diligently examined the Printed sheets.

In the following Treatise I have endeavoured to proceed methodically, and to insert every particular Chapter, as it ought to be read and practised, and have omitted nothing that might any way tend to make a man in short time become an exquisite proficient in the Geometrical part of Surveying.

The first Part of this Book consisteth of Geometry only, and containeth such Problemes as are meet and necessary to be known and practised by any man that intendeth to exercise himself in this employment: by help of these Problemes the Plot of any piece of Land may be enlarged or diminished according to any assigned proportion, and separation and division thereof made, if need be, by Rule and Compaſs only, and also by Arithmetick.

In the second Book, you have a general description of all the most necessary Instruments used in Surveying, as of the *Theodolite*, *Circumferentor*, *Plain Table*, and the like, and more particularly of those which I make use of in the prosecuting of this Discourse. Also I have given such directions for the making of the *Plain Table*, and furnished the Index and other parts thereof with divers necessarie lines for several occasions, so that it being made according to the directions there given, it is the most absolute and universal Instrument for all occasions yet ever invented; for by it may be performed whatsoever may be done by the *Theodolite*, *Circumferentor*, or *Peraſtor*, with the same facility and exactness, and in many cases better, as in the particular uses thereof will plainly appear.

And in the fifth Chapter of the second Book, I have described the making of an Instrument which will perform all the uses of the *Theodolite*, *Semicircle*, *Circumferentor*, and *Peraſtor*, and for Portability exceeds any of them. In the eighth Chapter of this second Book, there is also described a new kinde of *Protraſtor*, which is far more convenient for use then that which is usually made, and as is described in the former part of the said Chapter.

The third Book is of *Trigonometry*, or the Doctrine of the dimension of Plain Triangles, by *Sines*, *Tangents*, and *Logarithmes*, by which the nature & reason of the taking of all manner of Heights and Distances may the better appear, and for that reason I have in this third Book added short Tables of *Sines* and *Logarithmes*, namely, a Table of *Sines* to every ten minutes of the Quadrant, and a Table of *Logarithmes* from 1 to 1000, by which more Questions may be resolved in the space of one hour, then by the usual wayes taught by others can be performed in six, if the like exactness be required. And for a further abbreviation of these Calculations, I have also shewed how to resolve all such Cases in Plain Triangles as may at any time come in use in the practice of Surveying by the Lines of Artificial Numbers, *Sines*, and *Tangents*, whereby all
such

To the Reader.

such Cases may be resolved without Pen, Inke, or Paper.

In the fourth Book is shewn the use of all the fore-mentioned Instruments in the practice of surveying, and first in taking of all manner of Heights and Distances, either accessible or inaccessible, in the practice whereof the young Practitioner will take much delight, and receive no small satisfaction.

There is also taught how to take the Plot of any field or other inclosure several ways, both by the *Plain Table*, *Theodolite*, and *Circumferentor*, by which will appear what congruity and harmony there is between these several Instruments, for if you take the Plot of any field by any one of them, and then by another of them, and plot your work by the same Scale at both your observations, you shall (if you be careful) finde that these two Plots will agree together as exactly as if they had been both taken by one and the same Instrument. And for this reason I have made one Scheme or Figure serve for three several Chapters, which hath much abbreviated the number of Diagrams, and will (I perswade my self) give better satisfaction to the Learner, then variety of Figures could have done.

In the manner of protracting, when you have observed your degrees cut by the Needle in the *Circumferentor*, or the Index of the *Peraflor*, I have (because the practice thereof is very usual and no less difficult) in Page 239 inserted a Figure so plain and perspicuous, that the very sight thereof will be enough (if there were no words used) to explain the use thereof.

After the Plot of any field is taken and protracted according to any of the former directions, I come to shew how the content thereof may be attained several ways, that is, to finde how many Acres, Roods and Perches are contained in any Field thus plotted. Also there is taught how to measure Mountainous and uneven grounds, and to finde the area or content thereof.

You are also taught in this fourth Book how to take the true Plot of a whole Manor, or of divers severals, both by the *plain Table*, *Theodolite*, *Circumferentor* or *Peraflor*, with the manner how to keep account in your Field-Book after the most sure and exactest way. And here is also added a new way of Surveying of Land by the *Circumferentor* or *Peraflor*, by which when you have gone round about the field & made observation of the several sides and angles, you may with small trouble make examination thereof, and be satisfied whither your plot will close or not, before you begin to protract. Also how to reduce your Plot, to any proportion, to draw a perfect draught thereof, and to deck and beautifie the same, with the manner how to order such Colours as are necessary thereunto. And in the last place there is an example of Water-leveling, by which you may know whether water may be conveyed from a Spring-head to any determinate place or not.

Thus have I given you some general intimation of the principal heads contained in the following Treatise, which you may see more apparent in the following *Analysis*, but best of all in the Book it self,

To the Reader.

self, unto which I chiefly refer you, wishing that you may take the same delight and pleasure in the practice of those things therein contained, as I did in the composing of them, so shall I think my labour well bestowed, and be the more animated to present thee with some other Mathematical Treatise, who am

*A Friend to all that are
Mathematically
affected.*

London, June 1653

William Leybourn.



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Note that all Chapters and parts of Chapters that are added in this Edition, are noted with this mark before the Chapter 



Or as much as the whole
Art of Surveying, of
Land is performed by In-
struments of several kinds,
and that the exact and care-
ful making and dividing
of all such Instruments is
chiefly to be aimed at, I
thought good to intimate to such as are desirous to
practise this Art, and do not readily know where
to be furnished with necessary Instruments for the
performance thereof, that all, or any of Instru-
ments used or mentioned in this Book, or any Ma-
thematical Instruments whatsoever are most ex-
actly made by Mr. Anthony Thompson in
Hosier Lane neer Smithfield, London.



THE COMPLEAT SURVEYOR.

The First Book.

THE ARGUMENT.



His first *Book* consisteth of divers *Definitions* & *Problemes* *Geometricall*, extracted out of the *Writings* of divers ancient and modern *Geometricians*, as *Euclid*, *Ramus*, *Bagdeline*, *Clavius*, &c. and are here so methodically disposed, that any man may gradually proceed from *Probleme* to *Probleme* without interruption, or being referred to any other *Antbour* for the *Practicall* performance of any of them. Onely the *Demonstration* is wholly omitted; partly, because those *Books* out of

B

which

which they were extracted, are very large in that particular, and also for the avoiding of many other *Propositions* and *Theoremes*, which (had the ensuing *Problemes* been *demonstrated*) must of necessity have been inserted. Also, the figures would have been so incumbered with multiplicity of lines, that the intended *Problemes* would have been thereby much darkened. And besides it was not my intent in this place to make an absolute or entire *Treatise* of *Geometry*, and therefore I have onely made choice of such *Problemes* as I conceived most usefull for my present purpose, and come most in use in the practise of *Surveying*, and ought of necessity to be known by every man that intendeth to exercise himselfe in the Practise thereof, and those are chiefly such as concern the reducing of *Plots* from one forme to another, and to enlarge or diminish them according to any assigned *Proportion*, also divers of the *Problemes* in this *Eook* will abundantly help the *Surveyor* in the division and seperation of *Land*, and in the laying out of any assigned quantity, whereby large parcels may be readily divided into divers severals; and those again sub-divide if need be. Also for the better satisfaction of the *Reader*, I have performed divers of the following *Problemes* as well *Aritbmetically* as *Geometrically*.

G E-



GEOMETRICAL DEFINITIONS.

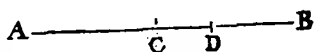
1 *A Point is that which cannot be divided.*



Point or *Signe* is that which is void of all *Magnitude*, and is the least thing that by minde and understanding can be imagined and conceived, than which there can be nothing lesse, as the *Point* or *Prick* noted with the letter A, which is neither quantity nor part of quantity, but only the terms or ends of quantity, and herein a *Point* in Geometry differeth from *Unity* in *Number*.

2 *A line is a length without breadth or thickness.*

A *Line* is created or made by the moving or drawing out of a *Point* from one place to another, so the *Line* A B, is made by moving of a *Point* from A to B, and according as this motion is, so is the *Line* thereby created, whether *streight* or *crooked*.



And of the three kinds of *Magnitudes* in *Geometry*, viz. *Length*, *Breadth*, and *Thicknesse*, a *Line* is the first, consisting of *Length* only, and therefore the *Line* A B, is capable of division in *Length* only, and may be divided equally in the *point* C, or unequally in D, and the like, but will admit of no other dimension.

3 *The ends or bounds of a Line are Points.*

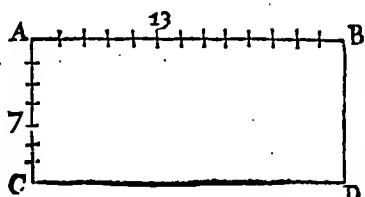
This is to be understood of a finite *Line* A ——— B only, as is the line A B, the ends or bounds whereof are the points A and B : But in a *Circular Line* it is otherwise,

wife, for there, the *Point* in its motion returneth again to the place where it first began, and so maketh the *Line* infinite, and the ends or bounds thereof undeterminate.

4 *A Right line is that which lieth equally between his points.*

A ————— B As the *Right line* A B lieth straight and equall between the points A and B (which are the bounds thereof) without bowing, and is the shortest of all other lines that can be drawn between those two points.

5 *A Superficies is that which hath only length and breadth.*



As the motion of a point produceth a *Line*, the first kinde of Magnitude, so the motion of a *Line* produceth a *Superficies*, which is the second kinde of Magnitude, and is capable of two dimensions, namely, length and breadth, and so the *Superficies* A B C D may be divided in length from A to B, and also in breadth from A to C.

6 *The extreames of a Superficies are Lines.*

As the extreames or ends of a *Line* are points, so the extreames or bounds of a *Superficies* are *Lines*, and to the extreames or ends of the *Superficies* A B C D, are the lines A B, B D, D C, and C A, which are the terms or limits thereof.

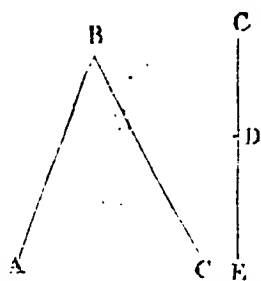
7 *A plain Superficies is that which lieth equally between his lines.*

So the *Superficies* A B C D, lieth direct and equally between his lines: and whatsoever is said of a right line, the same is also to be understood of a plain Superficies.

8 *A plain Angle is the inclination or bowing of two lines the one to the other, the one touching the other, & not being directly joyned together.*

As the two lines A B and B C incline the one to the other, and touch one another in the point B, in which point, by reason of the incli-

inclination of the said lines, is made the Angle ABC . But if the two lines which touch each other be without inclination, and be drawn directly one to the other, then they make no angle at all, as the lines CD and DE , touch each other in the point D , and yet they make no angle, but one continued right line.



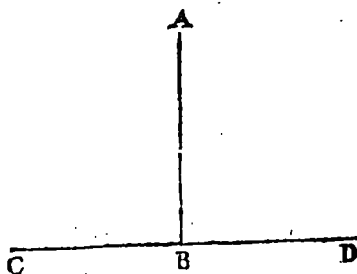
¶ And here note, that an Angle commonly is sign'd by three Letters, the middlemost whereof sheweth the angular point: As in this figure, when we say the angle ABC , you are to understand the very point at B : And note also, that the length of the sides containing any angle, as the sides AB and BC , do not make the angle ABC either greater or lesser, but the angle still retaineth the same quantity be the containing sides thereof either longer or shorter.

9 *And if the lines which contain the angle be right lines, then is it called a right lined angle.*

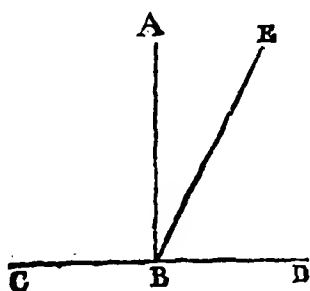
So the angle ABC is a right lined angle, because the lines AB and BC , which contain the said angle, are right lines. And of right lined Angles there are three sorts, whose Definitions follow.

10 *When a right line standing upon a right line maketh the angles on either side equall, then either of those angles is a right angle: and the right line which standeth erected, is called a perpendicular line to that whercon it standeth.*

As upon the right line CD , suppose there do stand another right line AB , in such sort that it maketh the angles on either side thereof equall, namely, the angle ABD on the one side, equall to the Angle ABC on the other side: then are either of the two angles ABC , and ABD right angles, and the right line AB , which standeth erected upon the right line CD , without inclining to either part thereof, is a perpendicular to the line CD .



11 *An Obtuse angle is that which is greater than a right angel.*



So the angle CBE is an obtuse angle, because it is greater than the angle ABC, which is a right angle; for it doth not only contain that right angle, but the angle ABE also, and therefore is obtuse.

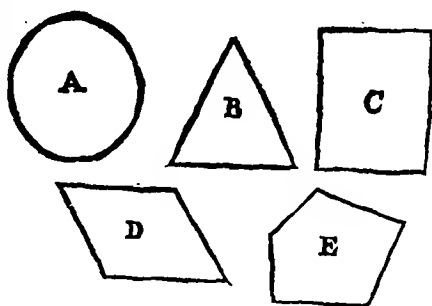
12 *An Acute angle is lesse than a right angle.*

So the angle EBD is an acute angle, for it is lesse than the right angle ABD (in which it is contained) by the other acute angle ABE.

13 *A limit or term is the end of every thing.*

As a point is the limit or term of a Line, because it is the end thereof, so a Line likewise is the limit and term of a Superficies; and a Superficies is the limit and term of a Body.

14 *A Figure is that which is contained under one limit or term or many.*



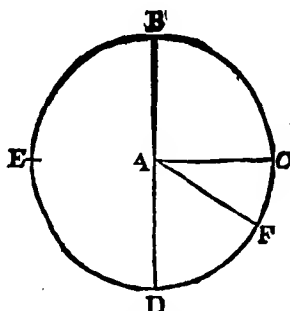
As the Figure A is contained under one limit or term, which is the round line. Also the Figure B is contained under three right lines, which are the limits or terms thereof. Likewise, the Figure C is contained under four right lines,

the Figure E under five right lines, and so of all other figures.

¶ And here note, that in the following work we call any plain Superficies whose sides are unequal, (as the figure E) a *Plot*, as of a Field, Wood, Park, Forrest, and the like,

- 15** *A Circle is a plain Figure contained under one line, which is called a Circumference, unto which all lines drawn from one point within the Figure, and falling upon the Circumference thereof are equal one to the other.*

As the figure A B C D E is a Circle, contained under the crooked line B C D E, which line is called the Circumference: In the middle of this Figure is a point A, from which point all lines drawn to the Circumference thereof are equal, as the lines A B, A C, A F, A D: and this point A is called the center of the Circle.



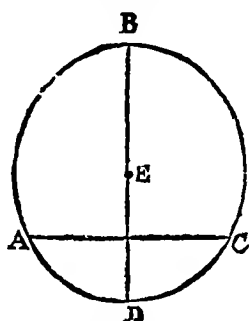
- 16** *A Diameter of a circle is a right line drawn by the Center thereof, and ending at the Circumference; on either side dividing the Circle into two equall parts.*

So the line B A D (in the former Figure) is the Diameter thereof, because it passeth from the point B on the one side of the Circumference, to the point D on the other side of the Circumference, and passeth also by the point A, which is the center of the Circle. And moreover, it divideth the circle into two equall parts, namely, B C D being on one side of the Diameter, equall, to B E D on the other side of the Diameter. And this observation was first made by *Thales Milesius*, for, saith he. If a line drawn by the center of any Circle do not divide it equally, all the lines drawn from the center of that Circle to the Circumference cannot be equal.

- 17** *A Semicircle is a figure contained under the Diameter, and that part of the Circumference, cut off by the Diameter.*

As in the former Circle, the figure B E D is a Semicircle, because it is contained of the right line B A D, which is the Diameter, and of the crooked line B E D, being that part of the circumference which is cut off by the Diameter: also the part B C D is a Semicircle.

18 *A Section or portion of a Circle, is a Figure contained under a right line, and a part of the circumference, greater or less then a Semicircle.*



So the Figure ABC , which consisteth of the part of the Circumference ABC , and the right line AC is a Section or portion of a Circle greater than a Semicircle.

Also the other figure ACD , which is contained under the right line AC , and the part of the circumference ADC , is a Section of a circle lesse than a Semicircle.

¶ And here note, that by a Section, Segment, Portion, or Part of a Circle, is meant the same thing, and signifieth such a part as is either greater or lesser then a Semicircle, so that a Semicircle cannot properly be called a Section, Segment, or part of a Circle.

19 *Right lined figures are such as are contained under right lines.*

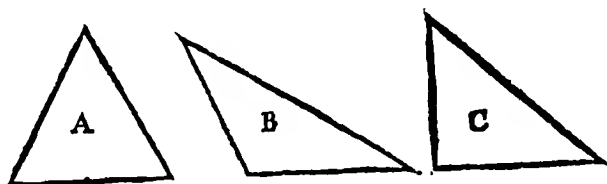
20 *Three sided figures are such as are contained under three right lines.*

21 *Four sided figures are such as are contained under four right lines.*

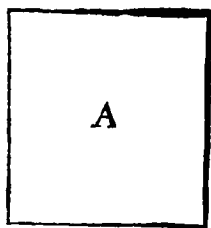
22 *Many sided figures are such as have more sides than four.*

23 *All three sided figures are called Triangles.*

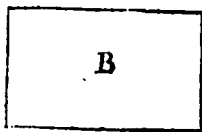
And such are the Triangles ABC .



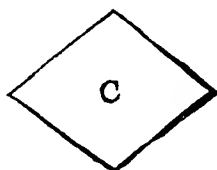
24 Of four sided figures,
a Quadrant or Square is
that whose sides are equal
and his angles right. As
the Figure A.



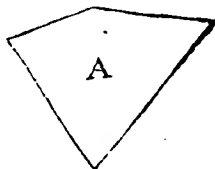
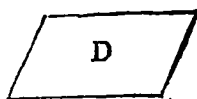
25 A Long Square is
that which bath right an-
gles but unequal sides. As
the Figure B.



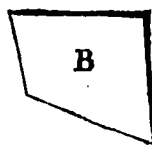
26. A Rhombus is a
Figure having four equall
sides but not right angles.
As the Figure C.



27 A Rhomboides is a
Figure whose opposite sides
are equall, and whose oppo-
site angles are also equall,
but it bath neither equall
sides nor equall angles.
As the Figure D.



28 All other Figures
of foure sides (besides these)
are called Trapezias.




Such are all Figures of four sides
in which is observed no equality of
sides or angles, as the figures A and
B, which have neither equall sides
nor equall angles, but are described
by all adventures without the ob-
servation of any order.

20 Parallel, or equidistant right lines are such which being in one and the same superficies, and produced infinitely on both sides, do never in any part concur.

A ——— B As the right lines A B and C D are parallel one to the other, and if they were infinitely extended on either side would never meet or concur together, but still retain the same distance.
C ——— D



Geometrical Theoremes.

- 1  Any two right lines crossing one another, make the contrary or vertical angles equal. Euclid 1.5.1.
- 2 If any right line fall upon two parallel right lines, it maketh the outward angles on the one, equal to the inward angles on the other, and the two inward opposite angles on contrary sides of the falling line also equal. Euclid. 29.1.
- 3 If any side of a Triangle be produced, the outward angle is equal to the two inward opposite angles, and all the three angles of any Triangle are equal to two right angles. Euclid. 32.1.
- 4 In equiangled Triangles, all their sides are proportional, as well such as contain the equal angles, as also the subtendent sides.
- 5 If any four Quantities be proportional, the first multiplied in the fourth, produceth a Quantity equal to that which is made by multiplication of the second in the third.
- 6 In all right angled Triangles, the square of the side subtending the right angle, is equal to both the squares of the containing sides. Euclid. 47.1.
- 7 All Parallelograms are double to the Triangles that are described upon their Bases, their Altitudes being equal. Euclid. 41.1.
- 8 All Triangles that have one and the same Base, and lie between two parallel lines, are equal one to the other. Euclid. 37.1.

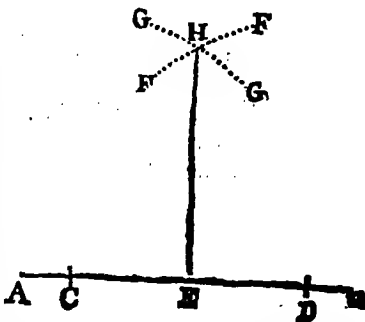


GEOMETRICALL PROBLEMES

PROBLEME I.

Upon a right line given, how to erect another right line, which shall be perpendicular to the right line given.

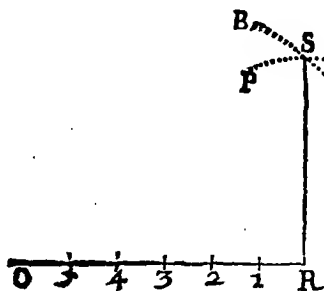
The right line given is A B, upon which from the point E it is required to erect the perpendicular E H. Opening your Compasses at pleasure to any convenient distance, place one foot in the assigned point E, and with the other make the marks C and D, Equidistant on each side the given point E. Then opening your Compasses again to any other convenient distance wider then the former, place one foot in C, and with the other describe the arch G G, also (the Compasses remaining at the same distance) place one foot in the point D, and with the other describe the arch F F, then from the point where these two arches intersect or cut each other (which is at H) draw the right Line H E which shall be perpendicular to the given right line A B, which was the thing required to be done.



PROB. II.

How to erect a Perpendicular on the end of a right line given.

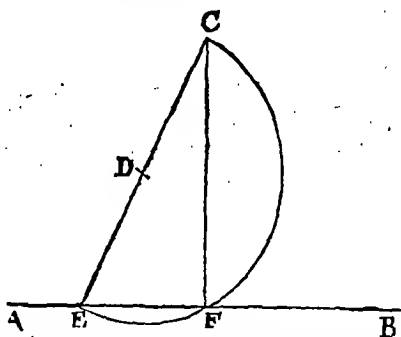
LET OR be a line given, and let it be required to erect the perpendicular RS . First, upon the line OR , with your Compasses opened to any small distance, make five small divisions beginning at R , noted with 1, 2, 3, 4, 5. Then take with your Compasses the distance from R to 4, and placing one foot in R , with the other describe the arch PP . Then take the distance $R5$, and placing one foot of The Compasses in 3, with the other foot describe the arch BB , cutting the former arch in the point S . Lastly from the point S , draw the line RS , which shall be perpendicular to the given line OR .



PROB. III.

How to let fall a perpendicular, from any point assigned, upon a right line given.

THE point given is C , from which point it is required to draw a right line which shall be perpendicular to the given right line AB .



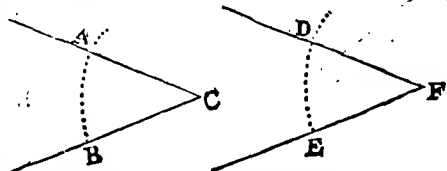
First, from the given point C , to the line AB , draw a line by chance, as CE , which divide into two equall parts in the point D , then placing one foot of the Compasses in the point D , with the distance DC , describe the Semicircle CFE , cutting the given line AB in the point F . Lastly, if from the point C you draw the right line CF , it shall be a perpendicular to the given line AB , which was required.

PROB. IV.

How to make an angle equall to an angle given.

Let the angle given be ACB , and let it be required to make another angle equall thereunto.

First, draw the line EF at pleasure, then upon the given angle at C , (the Compasses opened to any distance) describe the ark



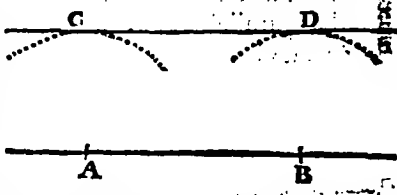
AB , also; upon the point F (the Compasses un-altered) describe the arke DE : then take with your Compasses the distance AB , and set the same distance from E to D . Lastly, draw the line DF , so shall the angle DFE be equall to the given angle ACB .

PROB. V.

A right line being given, how to draw another right line which shall be parallel to the former, at any distance required.

The line given is AB , unto which it is required to draw another right line parallel thereunto, at the distance AC , or BD .

First, Open your Compasses to the distance AC or AD , then placing one foot in A , with the other describe the arke C ; also place one foot in B , and with the other describe the Arch D . Lastly,



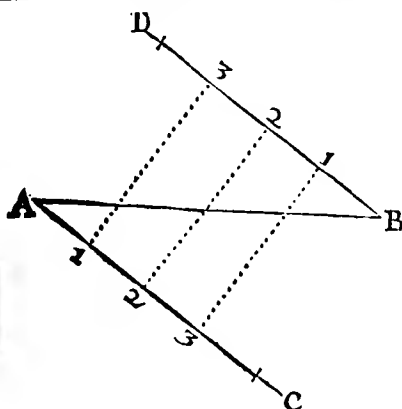
Draw the line CD so that it may only touch the arks C and D so shall the line CD be parallel to the line AB , and at the distance required.

PROB VI.

To divide a right line given into any number of equall parts.

Let AB be a right line given, and let it be required to divide the same into four equall parts.

First,

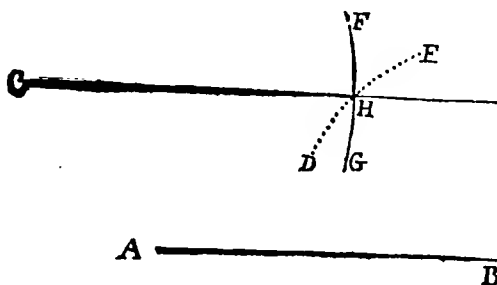


First, from the end of the given line A, draw the line A C, making any angle, then from the other end of the given line, which is at the point B, draw the line B D parallel to A C, (or make the angle A B D equal to the Angle C A B;) then upon the lines A C and B D set off any three equal parts which (is one less than the number of parts into which the line A B is to be divided) on each line, as 1 2 3, then draw lines from 1 to 3, from 2 to 2, and from 3 to 1, which lines, crossing the given line A B, shall divide it into four equal parts as was required.

PROB. VII.

A right line being given, how to draw another right line parallel thereunto, which shall also passe through a point assigned.

L Et A B be a line given; and let it be required to draw another line parallel thereunto which shall passe through the given point C.



line A B, and placing one foot in the point C, with the other describe the arke F G, crossing the former arke D E in the point H. Lastly, if you draw the Line C H it shall be parallel to A B.

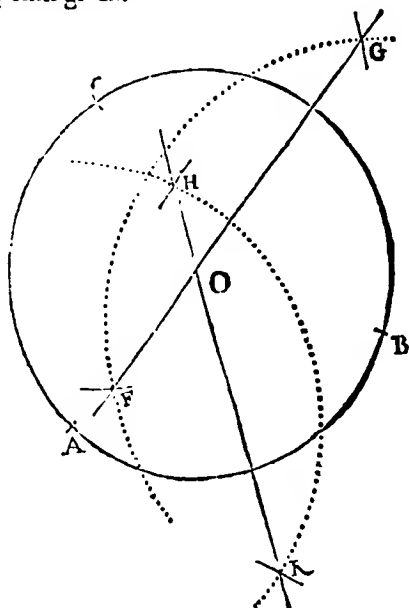
First, Take with your compasses the distance from A to C, and placing one foot thereof in B, with the other describe the arke D E; then take in your compasses the whole

PROB. VIII.

Having any three points given, which are not situate in a right line, how to finde the center of an arch of a Circle which shall pass directly through the three given points.

THe three points given are A B and C, now it is required to finde the center of a Circle, whose circumference shall pass through the three points given.

First, open your Compasses to any distance greater then half the distance between B and C, then place one foot in the point B, and with the other describe the arch F G, then the compasses remaining at the same distance, place one foot in C, and with the other turned about make the marks F and G in the former arch, and draw the line F G at length if need be.



Again, opening the Compasses to any distance greater then half A B, place one foot in the point A, and with the other describe the arch H K, then the Compasses remaining at the same distance, place one foot in the point B, and turning the other about make the marks H K in the former arch.

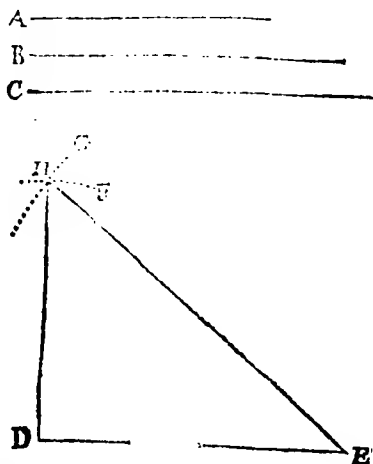
Lastly, draw the right line H K cutting the line F G in O, so shall O be the center upon which if you describe a circle at the distance of O A, it shall pass directly through the three given points A B C, which was required.

PROBLEME IX.

Any three right lines being given, so that the two shortest together be longer then the third, to make thereof a Triangle.

Let it be required to make a Triangle of the three lines A B and C, the two shortest whereof, viz. A and B together, are longer then the third line C.

First,



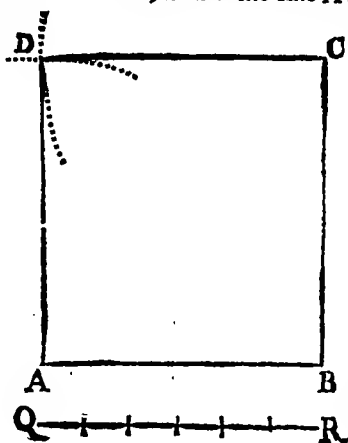
First, Draw the line DE equal to the given line B, then take with your Compasses the line C, and setting one foot in E, with the other describe the arch HG, also, take the given line A in your Compasses, and placing one foot in D, with the other describe the arch HF, cutting the former arch HG in the point H. Lastly, if from the point H you draw the lines HE and HD, you shall constitute the Triangle HDE, whose sides shall be equal to the three given lines ABC.

PROB. X.

Having a right line given, how to make a Geometricall Square, whose side shall be equal to the Right line given.

The line given is QR, and it is required to make a Geometricall Square whose side shall be equal to the line QR.

First, Draw the line AB, making it equal to the given line QR, then (by the first or second Probleme) upon the point B raise the perpendicular BC, making the line BC equal to the given line QR also. Then taking the line QR in your Compasses, place one foot in C, and with the other describe the arch D, also the Compasses so resting, place one foot in A, and with the other describe another arch crossing the former in the point D. Lastly, draw the lines DC and DA, which shall include the Geometricall square ABCD.



PROB.

PROB. XI.

Two right lines being given how to finde a third right line which shall be in proportion unto them.

Let the two given lines be A and B required to finde a third line which shall be in proportion unto them.

First, Draw two right lines making any angle at pleasure, as the lines OP and ON, making the angle PON; then taking the line A in your Compasses, set the length thereof from O to S, also, take the line B in your Compasses, and set the length thereof from O to R, and also from O to D, then draw the right line SD, and from the point R draw the right line RC parallel to SD, so shall OC be the third proportional required.

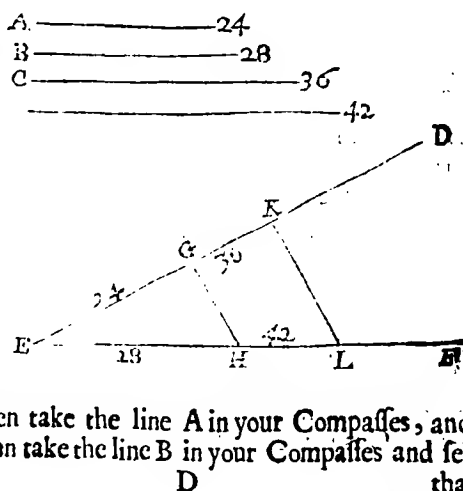
$$\begin{array}{cccc} \text{As OS} & \text{to OD} & :: & \text{so OR to OC.} \\ 8 & 12 & & 12 \quad 18 \end{array}$$

PROB. XII.

Three right lines being given, to finde a fourth in proportion to them.

THE three lines given are ABC, unto which it is required to finde a fourth proportionall line. This is to perform the rule of three in lines.

As in the last Problem, you must draw two lines making any angle, as the angle DEF. Then take the line A in your Compasses, and set it from E to G, then take the line B in your Compasses and set that



that length from E to H. Then take the third given line in your Compasses, and set that from E to K, and through that point K draw the line K L parallel to G H, so shall the line E L be the third proportional required; for,

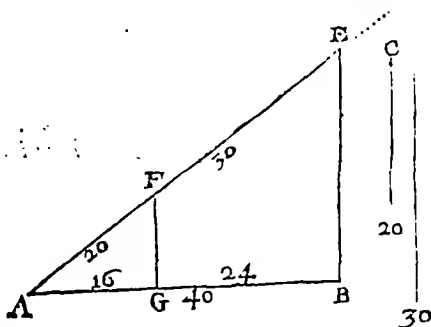
$$\begin{array}{cccc} \text{As EG to EH} & :: & \text{so EK to EL.} \\ 24 & 28 & 36 & 42. \end{array}$$

Here note that in the performance of this Probleme, that the first and the third terms (namely, the lines A and C) must be set upon one and the same line, as hereupon the line E D, and the second term (namely, the line B) must be set upon the other line E F, upon which line also the fourth proportional E L will be found.

PROBLEME XIII.

To divide a right line given into two parts, which shall have such proportion one to the other as two given right lines.

The line given is A B, and it is required to divide the same into two parts, which shall have such such proportion one to the other, as the line C hath to the line D.



First, from the point A, draw the line A E, at pleasure, making the angle E A B; then take in your Compasses the line C, and set it from A to F, also take the line D, and set it from F to E, and draw the line E B, then from the point F, draw the line F G parallel to E B, cutting the

given line A B in the point G; so is the line A B divided into two parts in the point G, being in proportion one to the other, as the line C is to the line D; for,

$$\text{As AE to AB} :: \text{so AF to AG.}$$

Arithmetically.

Let the line A B contain 40 Perches, and let the line C be 20, and the line D 30; and let it be required to divide the line A B into two parts, being in proportion one to the other, as the line C is to the line D.

First,

First, Add the lines C and D together, their sum is 50, then say by the Rule of Proportion : If 50 (which is the sum of two given terms) give 40 the whole line A B, what shall 30, the greater given term give? Multiply and divide, and you shall have in the quotient 24 for the greater part of the line A B, which being taken from 40 the whole line, there remains 16 for the other part A G; for,

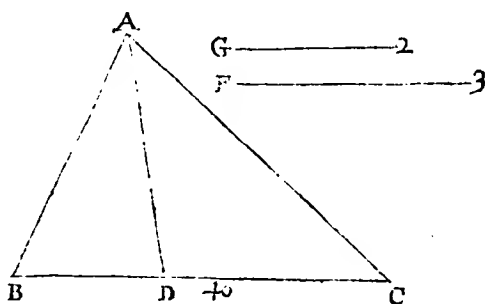
As A E to A B :: so F E to G B.

50 40 30 24

PROBLEME XVI.

How to divide a Triangle into two parts, according to any proportion assigned, by a line drawn from any Angle thereof, and to lay the lesser part towards any side assigned.

Let A B C be a Triangle given, and let it be required to divide the same, by a line drawn from the angle A, into two parts, the one bearing proportion to the other, as the line F doth to the line G, and that the lesser part may be towards the side A B.



By the last *Probleme* divide the base of the Triangle B C in the point D, in proportion as the line F is to the line G, (the lesser part being set from B to D). Lastly, draw the line A D, which shall divide the Triangle A B C in proportion as F to G; for,

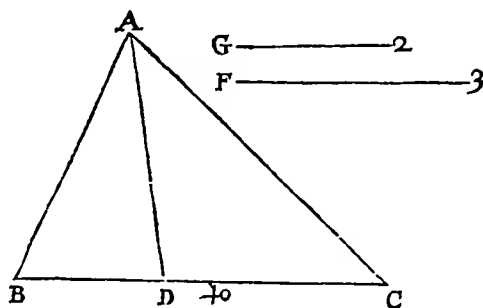
As the line F, is to the line G;

So is the Triangle A D C; to the Triangle A B D.

PROB. XV.

The Base of the Triangle being known, to perform the foregoing Probleme by Arithmetick.

Suppose the Base of the Triangle BC to be 40, and let the proportion into which the Triangle ABC is to be divided, be as 2 to 3.



First, Add the two proportional terms together, 2 and 3, which makes 5, then say by the Rule of Proportion : If 5 (the sum of the proportional terms,) give 40 (the whole base BC) what shall 3 (the greater term given) ? Multiply and divide, and the quotient will give you 24 for the greater segment of the Base DC, which being deducted from the whole Base 40, there will remain 16 for the lesser segment BD.

PROB. XVI.

How to divide a Triangle, whose area or content is known, into two parts, by a line drawn from an Angle assigned, according to any proportion required.

Let the Triangle ABC contain 8 Acres, and let it be required to divide the same into two parts, by a line drawn from the Angle A, the one to contain 5 Acres, and the other 3 Acres.

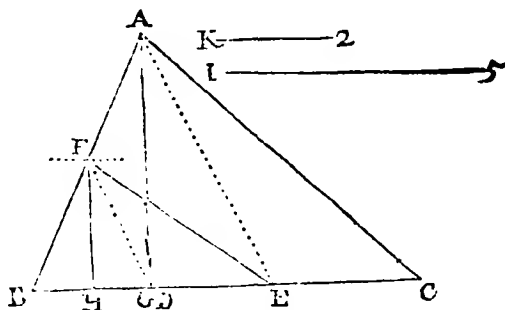
First, Measure the whole length of the Base, which suppose 40, then say, If 8 Acres (the quantity of the whole Triangle) give 40, (the whole Base,) what parts of the Base shall 5 Acres give ? Multiply and divide the Quotient will be 25 for the greater Segment of the Base CD, which being deducted from 40 (the whole Base,) there will remain 15 for the lesser Segment of the Base BD, then draw

draw the line A D, which shall divide the Triangle A B C according to the proportion required.

PROB. XVII.

How to divide a Triangle given into two parts, according to any proportion assigned, by a line drawn from a point limited in any of the sides thereof: and to lay the greater or lesser part towards an Angle assigned.

THe Triangle given is ABC and it is required from the point E, to draw a line that shall divide the Triangle into two parts, being in proportion one to the other as the line I is to the line K, and to lay the lesser part towards B.



First, From the limited point E, draw a line to the opposite Angle at A; then divide the Base B.C in proportion as I to K, which point of division will be at D, then draw D F parallel to A E. Lastly, from F draw the line F E, which will divide the Triangle into two parts being in proportion one to the other, as the line I is to the line K.

PROB. XVIII.

To perform the foregoing Probleme Arithmetically.

IT is required to divide the Triangle ABC, from the point E, into two parts in proportion as 5 to 2.

First, Divide the Base BC according to the given proportion, then (because the lesser part is to be laid towards B) measure the distance from E to B, which admit 30, then say by the Rule of Proportion; If E B 30, give D B 15 what shall AG 29 (the perpendicular

lar

lar of the Triangle) give? Multiply and divide, the Quotient will be 14, at which distance draw a parallel line to BC, namely F, then from F draw the line FE, which shall divide the Triangle according to the required proportion,

PROB. XIX.

How to divide a Triangle, whose area or content is known, into two parts, by a line drawn from a point limited in any side thereof, according to any number of Acres, Roods and Perches.

IN the foregoing Triangle ABC, whose area or content is five Acres, 1 Rood, let the limited point be E in the base thereof, and let it be required from the point E to draw a right line which shall divide the Triangle into two parts between M and P, so that M may have 3 Acres, 3 Roods thereof, and P may have 1 Acre and 2 Roods thereof.

First, reduce the quantity of P (being the lesser) into Perches, which makes 240, then (considering on which side of the limited point E this part is to be laid, as towards B) measure that part of the Base from E to B 30 Perches, whereof take the half, which is 15, and thereby divide 240, the part belonging to P; the quotient will be 16, the length of the perpendicular FH, at which parallel distance from the Base BC cut the side AB in F, from whence draw the line FE which shall cut off the Triangle FBE, containing 1 Acre, 2 Roods, the part belonging to P, then will the Trapezia AFEC (which is the part belonging to M) contain the residue, namely, 3 Acres, 3 Roods.

PROB. XX.

How to divide a Triangle according to any proportion given, by a line drawn parallel to one of the sides given.

THe following Triangle ABC is given, and it is required to divide the same into two parts by a line drawn parallel to the side AC, which shall be in proportion one to the other, the line I is to the line K.

First (by the 13 Problem) divide the line BC in E, in proportion as I to K, then (by the 24 Problem following) find a mean proportional between BE and BC, which let be BF from which point F, draw the line FH parallel to AC, which line shall divide the Triangle into two parts, viz. the Trapezia AHFC, and the

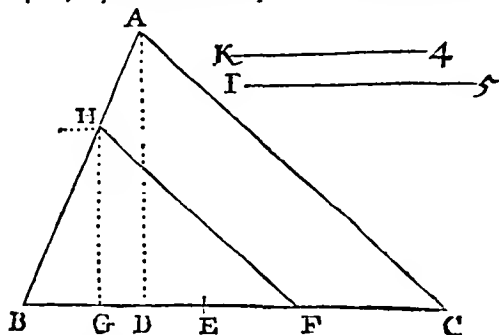
Tri-

Triangle H F B, which are in proportion one to the other as the line I is to the line K,

PROB. XXI.

To perform the foregoing Probleme Arithmetically.

Let the Triangle be A B C, and let it be required to divide the same into two parts, which shall be in proportion one to the other, as 4 to 5, by a line drawn parallel to one of the sides.



First, Let the base B C containing 54 be divided according to the proportion given, so shall the lesser segment B E contain 24, and the greater E C 30; then find out a mean proportionall line between B E 24, & the whole base B C 54, by multiplying 54 by 24, whose product will be 1296, the square root whereof is 36, the mean proportionall sought, which is B F, then, by the rule of proportion say: If B F 36, give B E 24, what A D 36? the answer is H C 24, at which distance draw a parallel line to the base, to cut the side A B in H, from whence draw the line H F parallel to A C, which shall divide the Triangle as was required,

PROB. XXII.

To divide a Triangle of any known quantity, into two parts, by a line drawn parallel to one of the sides, according to any number of Acres, Roods, and Perches.

The Triangle given is A B C, whose quantity is 8 Acres, 0 Roods, 16 Perches, and it is required to divide the same (by a line drawn parallel to the side A C) into two parts, viz. 4 Acres, 2 Roods, 0 Perches, and 3 Acres, 2 Roods, 16 Perches.

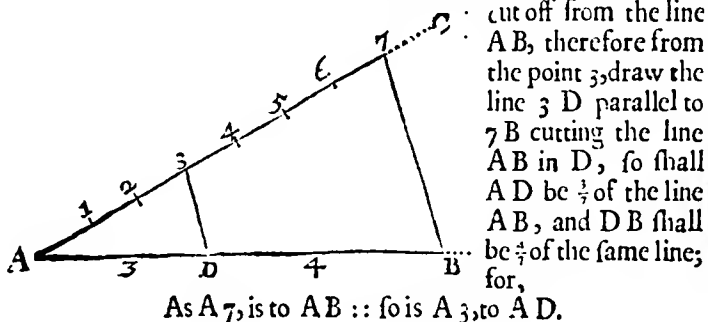
First,

First, Reduce both quantities into perches (as is hereafter taught) and they will be 720, and 576, then reduce both those numbers, by abbreviation, into the least proportional terms, *viz.* 5 and 4, and according to that proportion, divide the base BC 54 of the given Triangle in E, then seek the mean proportional between BE and BC, which proportional is BF 36, of which 36 take the halfe, and thereby divide 576, the lesser quantity of Perches, the Quotient will be HG 32, at which parallel distance from the base, cut off the line AB in H, from whence draw the line HF parallel to the side AC, which shall divide the Triangle given according as was required.

PROB. XXIII.

From a line given, to cut off any parts required.

THe line given is AB, from which it is required to cut off $\frac{1}{7}$ parts. First, draw the line AC, making any angle, as CAB, then from A, set off any seven equal parts, as 1 2 3 4 5 6 7, and from 7 draw the line 7B. Now because $\frac{1}{7}$ is to be



PROB. XXIV.

To find a mean proportional between two lines given.

IN the following figure, let the two lines given be A and B, between which it is required to find a mean proportional.

Let the two given lines A and B, be joyned together in the point E, making one right line, as CD which divide into two equal parts in the point G, upon which point G, with the distance GC or GD, describe the Semicircle CFD, then, from the point E, (where the two lines are joyned together) raise the perpendicular EF, cutting the Periphery of the Semicircle in F, so shall the line

EF

EF be a mean proportional between the two given lines A and B;
for,

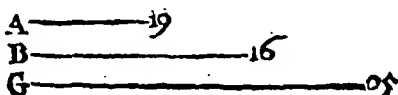
$$\text{As ED to EF} :: \text{so EF to CF.}$$

$$9 \quad 12 \quad 12 \quad 16$$

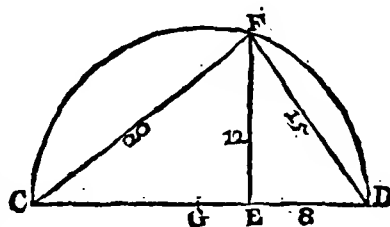
PROB. XXV.

*How to find two lines which together shal be equal
in power to any line given, and in power the
one to the other according to any proportion
assigned.*

IN this figure let CD
be a line given to be
divided in power as



the line A is to the line B.
First, Divide the line
CD in the point E, in
proportion as A to B, (by
the 13 Probleme) then di-
vide the line CD into
two equal parts in the
point G, and on G, at the
distance GC or GD, de-
scribe the semicircle CF,
D, and upon the point E,



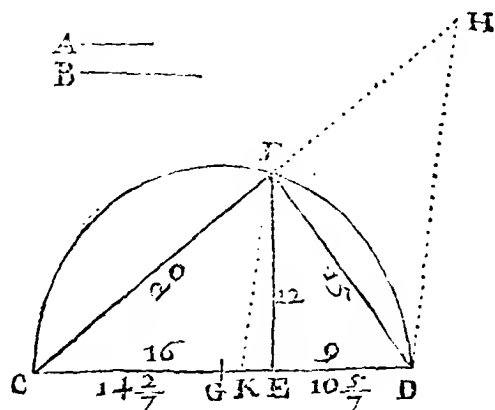
raise the perpendicular EF, cutting the Semicircle in F: Lastly
draw the lines CF and DF, which together in power wall be
equall to the power of the given line CD, and yet in power one
to the other as A to B.

E

PROB.

PROB. XXVI.

How to divide a line in power according to any proportion given.



First, divide the line CD in the point E in proportion as A to B , then divide the line CD in two parts in the point G , and upon G as a center at the distance GD , describe the semicircle CFD , and on the point E raise the perpendicular of EF cutting the semicircle in F , then draw the lines CF and DF , and produce the line CF to H , till FH be equal to FD , and draw the line BD , and FK parallel to HD , then shall the line CD be divided in K , so that the square of CK shall be to the square of KD , as CE to ED , or as B to A .

PROB. XXVII.

How to enlarge a line in power, according to any proportion assigned.

IN the Diagram of the 25th. Probleme, let CE be a line given, to be enlarged in power as the line B to the line G .

First, (by the 13th. Probleme) find a line in proportion to the given line CE , as B is to G , which will be CD , upon which line describe the semicircle CFD , and on the point E , erect the perpendicular EF ; then draw the line CF , which shall be in power to CE , as G to B .

PROB. XXVIII.

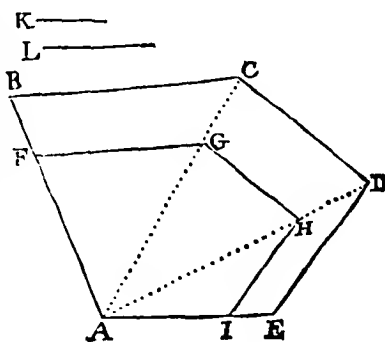
To enlarge or diminish a Plot given, according to any proportion required.

L Et ABC DE be a Plot given, to be diminished in power a L to K.

Divide one of the sides (as A B) in power as L to K, in such sort, that the power of A F, may be to the power of A B, as L to K. Then from the angle A, draw lines to the points C and D, that done, by F draw a parallel to B C, to cut A C in G, as F G. Again, from G, draw a parallel to D C, to cut in A D in H. Lastly, from H, draw a parallel to D E, to cut A E in I, so shall the plot A F G H I be like A B C D E, and in proportion to it, as the line L, to the line K which was required.

Also, if the lesser Plot were given, and it were required to make a greater in proportion to it as K to L.

Then from the point A, draw the lines A C and A D, at length, also increase A F and A I: that done, enlarge A F in power as K to L, which set from A to B, then by B draw a parallel to F G to cut A C in C, as B C. Likewise from C



draw a parallel to G H, to cut A D in D, as C D. Lastly, a parallel from D to H I, as A D E, to cut A I being increased in E, so shall you include the Plot A B C D E, like A F G H I, and in proportion thereunto, as the line K is to the L, which was required.

PROB. XXIX.

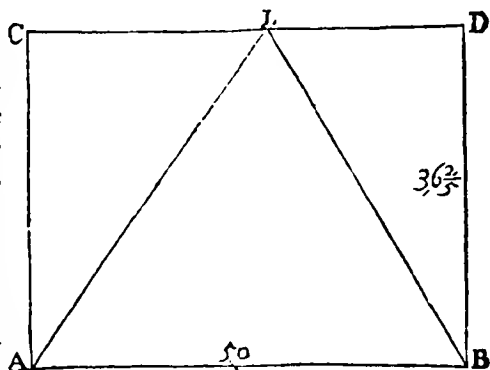
How to make a Triangle which shall contain any number of Acres, Roods and Perches and whose base shall be equal to any (possible) number given.

I F it be required to make a Triangle which shall contain 5 Acres, two Roods, 30 Perches, whose base shall contain 50 Perches, you must first reduce your 5 Acres, 2 Roods, 30 Perches, all into Perches in this manner.

First, (because 4 Roods make one Acre) multiply your 5 Acres by 4 which makes 20, to which add the two odd Roods, so have

you 22 Roods in your 5 Acres, 2 Roods. Then (because 40 Perches make one Rood) multiply your 22 Roods by 40, which makes 880 Perches, to which add the 30 odd Perches, and you shall have 910, and so many Perches are contained in 5 Acres, 2 Roods, 30 Perches.

Now to make a Triangle which shall contain 910 perches, & whose base shall be 50 Perches, do thus, Double the number of perches given, namely 910, and they make 1820, then because the base of the triangle must



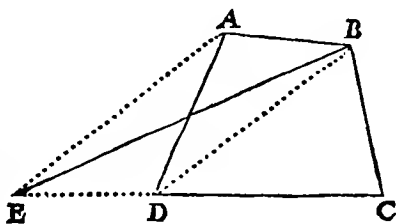
contain 50 Perches, divide 1820 by 50, the quotient will be $36\frac{2}{5}$, which will be the length of the perpendicular of your Triangle. This done, From any equal Scale lay down the line AB equal to 50 Perches, then upon B, raise the perpendicular BD equal to $36\frac{2}{5}$ perches, and draw the line CD parallel to AB: then, from any point in the line CD (as from E) draw the lines EA and EB, including the Triangle AEB, which shall contain 5 Acres, 2 Roods, 30 Perches which was required.

PROB. XXX.

How to reduce a Trapezia into a Triangle, by a line drawn from any angle thereof.

THe Trapezia given is ABCD, and it is required to reduce the same into a Triangle.

First, Extend the line DC, and draw the Diagonall BD, then from the point A, draw the line AE parallel to BD, extending it till it cut the side CD in the point E. Lastly, from B, draw the line BE, constituting the Triangle EBC, which shall be equal to the Trapezia ABCD.

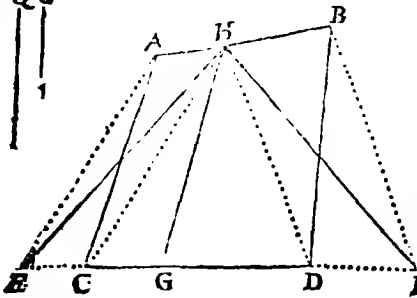
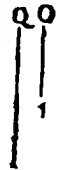


PROB.

PROB. XXXI.

How to reduce a Trapezia into a Triangle, by lines drawn from any point in any of the sides thereof

Let $ABCD$ be a Trapezia given, and let H be a point in one of the sides thereof from which point H let it be required to draw lines which shall reduce the Trapezia into a Triangle.



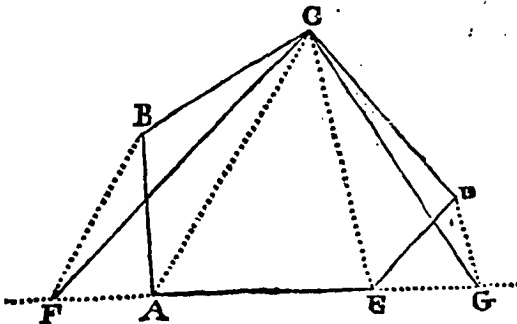
First, Extend the side which is opposite to the given point, namely, the side CD , both ways to E and F , and then from the point H , draw lines to the Angles C and D , as the lines HG and HD ; also, draw the lines AE and BF parallel to HC and HD , cutting the extended line CD in the points E and F . Lastly, If from the point H you draw the lines HE and HF you shall constitute the Triangle HEF , which shall be equal to the Trapezia $ABCD$.

PROB. XXXII.

How to reduce an irregular Plot of five sides into a Triangle.

The irregular Plot given is $ABCDE$, and it is required to reduce the same into a Triangle.

First, extend the side AE both ways to F and G , and from the Angle C , draw the lines CA and CE , to the Angles A and E . Then from the point B , draw the line BF parallel to CA



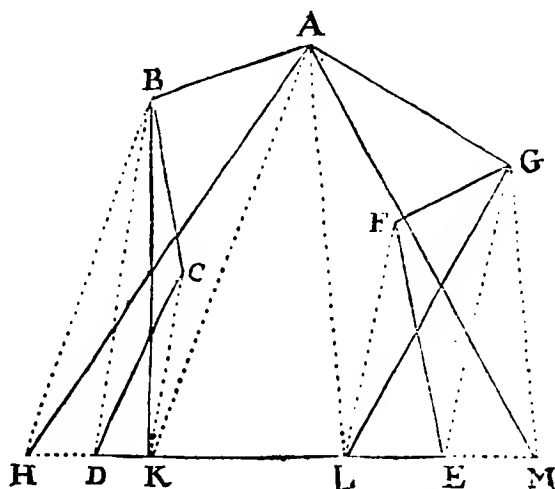
cutting

cutting the extended side AE , in F ; also from the point D , draw the line DG parallel to CE , cutting also the extended side in G . Lastly, from the angle C , draw the lines CF and CG , constituting the Triangle CFG , which is equal to the Plot $ABCDE$.



PROB. XXXIII.

How to reduce an irregular Plot of 6, 7, or 8 sides into a Triangle.



L Et $ABCDEFG$ be an irregular plot given, to be reduced into a Triangle.

I have chosen this figure where the angles C and D are without the field, because it often comes in practice, and hath not been taught by any to my knowledge.

First, draw the lines BD , and parallel thereto the lines CK , then if you draw the line BK , the two sides BC and CD shall be reduced to one right line, *viz.* to the line BK . Also draw the line GE , and parallel thereto FL , then if you draw the line GL , the two sides GF and FE shall be reduced to one straight line, *viz.* to the line GL , and so the whole plot $ABCDEFG$ consisting of seven sides, is reduced to a figure of five sides, namely, to the figure $ABKLG$; yet still retaining the same quantity. Now to reduce this plot into a Triangle you must work in all respects as in the former Problem. First, produce the side DE of the given figure, on both sides to H and M , then draw lines AK and AL , and parallel to them, the lines BH and GM , cutting the line DE being extended in H and M . Lastly, if you draw the lines AH and AM , you shall constitute the Triangle AHM which shall be equal to the irregular plot $ABCDEFG$ which was required.

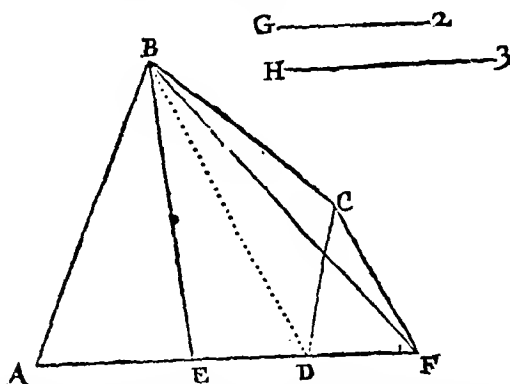
And

And here note that the number of sides be never so many; yet this way of reduction will bring them to Triangles, and the more outward angles there are in the Plot, the more troublesome will it be to effect.

PROB. XXXIV.

A Trapezia being given, how from any angle thereof to divide the same into two parts being in proportion one to the other as two given right lines, and to set the part cut off towards an assigned side.

Let the Trapezia given be $ABCD$, and let it be required to draw a line from the angle B , which shall divide the Trapezia into two parts, being in proportion one to the other, as the line G is to the line H , and that the lesser part of the figure cut off, may be towards the side AB .



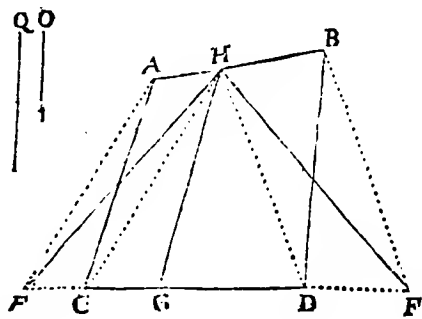
First, (by the 29 *Probleme*) reduce the Trapezia $ABCD$ into a Triangle, by drawing the line BF from the assigned angle; thereby constituting the Triangle ABF , equal to the Trapezia $ABCD$: this done, divide the base of the Triangle AF in proportion as G to H , which will be in the point E . Lastly, draw the line BE , which shall divide the Trapezia in proportion as G to H . Now because the lesser part of the Trapezia was to be set towards the side AB , therefore the lesser part of the line must be set from A to E . Here note that the same manner of working is to be observed, if it had been required to divide the Trapezia by a line drawn from any of the other angles.

PROB.

PROB. XXXV.

A Trapezia being given, how, from a point limited in any side thereof, to draw a line which shall divide the same into two parts in proportion as two given lines.

THe Trapezia given is A B C D, and it is required from the point H, to draw a line which shall divide the Trapezia in proportion as O to Q.



First, Prolong the side CD , and reduce the whole Trapezia into the Triangle HEF by the 30 *Probleme*, then divide the line EF in proportion as O to Q , which will fall in the point G , therefore draw the line HG , which shall divide the Trapezia into two parts in proportion as O to Q , which was required.

PROB. XXXVI.

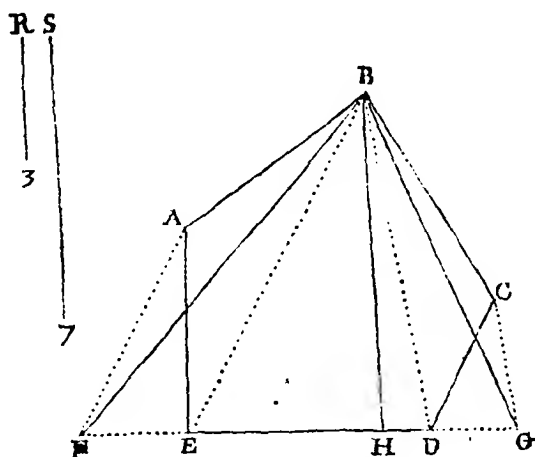
A Trapezia being given, how to divide the same into two parts in proportion as two lines given, and so that the line of partition may be parallel to any side thereof.

THe Trapezia given is A B C D, and it is required to divide the same into two parts, which shall be in proportion one to the other as the line K is to the line L, and that the line of partition may be parallel to the side B D.

Consider first, through which sides of the Trapezia the line of partition will pass, as in this figure it will pass through the sides AB and CD (because parallel to BD ,) therefore, extend the sides AB and CD , till they concur in E ; then (*by the 32 Probleme*) reduce the Trapezia $ABCD$ into the Triangle BGD , whose base is GD , which line GD , divide the point H in proportion as K to L ; so that,

As K to L :: So DH to HG.

This

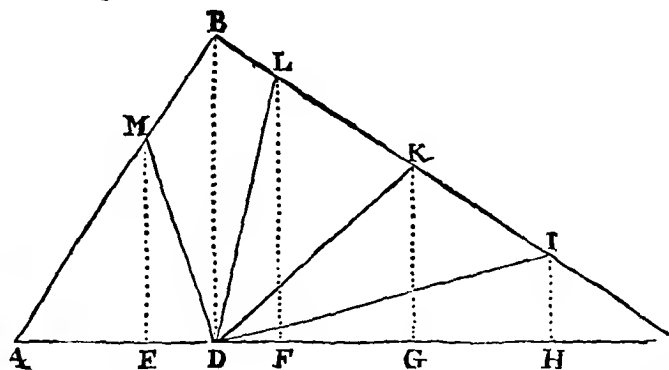


PROB. XXXVIII.

How to divide a Triangle into any number of equal parts, by lines drawn from a point given in any side thereof.

Let it be required to divide the Triangle, ABC into five equal parts, by lines drawn from the point D .

First, From the given point D , to the opposite angle B , draw the line DB , then divide the side AC of the Triangle into five equal parts, at E , F , G , and H , and through each of those points draw lines parallel to DB , as EM , FL , GK , and HI : then from the point D , draw the lines DI , DK , DL , and DM , which shall divide the Triangle ABC into five equal parts from the point D , as was required.

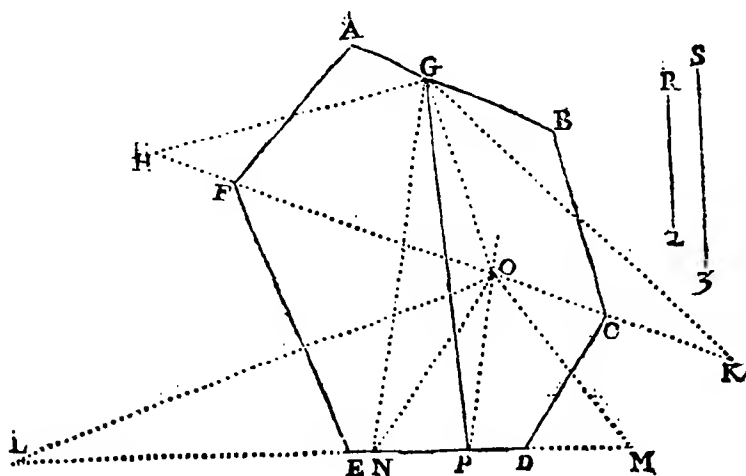


PROB.

PROB. XXXIX.

How to divide an irregular Plot of six sides, into two parts, according to any assigned proportion, by a right line drawn from a point limited in any of the sides thereof.

THe irregular Plot given is $ABCDEF$, and it is required to divide the same into two parts, being in proportion one to the other, as the line R is to the line S .



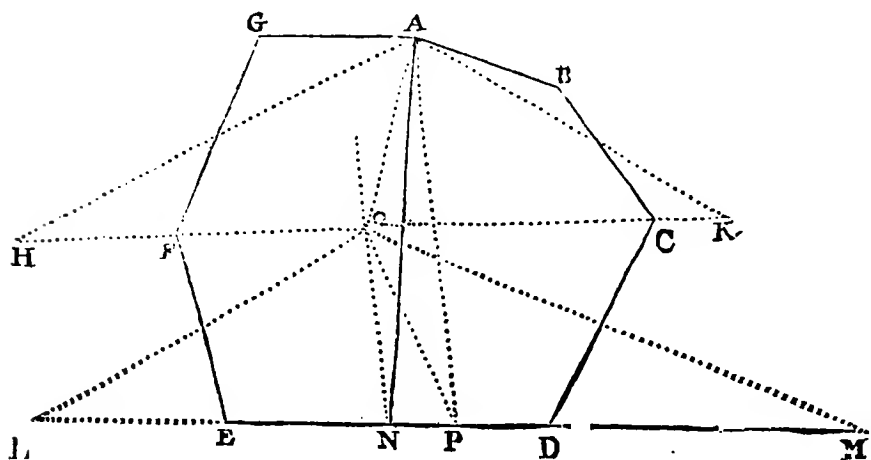
First, Draw the right line HK , and (by the 30th. Probleme) reduce the Trapezia $ABFG$ into the Triangle HGK , then divide the base thereof, namely, HK , into two parts in proportion as R to S , which will be in the point O , then draw the line GO , which will divide the Trapezia $ABFC$ into two parts in proportion one to the other, as the line R is to the line S .

Secondly, From the point O (by the 31. Probleme) reduce the Trapezia $FCEd$ into the Triangle OLM , and divide the base thereof, namely, LM , in the point N , in proportion as R to S , and draw the line ON , which will divide the Trapezia $FCEd$ into two parts in proportion as R to S : and by this means is the whole Plot $ABCDEF$ divided into two parts in proportion as R to S , by the lines GO and ON . But it is required to resolve the Probleme by one right line only drawn from the point G , therefore, from the point G , draw the line CN , and through the point O , draw the line OP parallel to GN : and lastly, from G , draw the right line GP , which shall divide the whole Plot $ABCDEF$ into two parts, being in proportion one to the other as the line T is to the line S .

PROB. XL.

How to divide an irrègular Plot according to any proportion, by a line drawn from any Angle thereof.

L Et ABCDEFG be an irrègular Plot, and let it be required to divide the same into two equal parts, by a line drawn from the angle A.

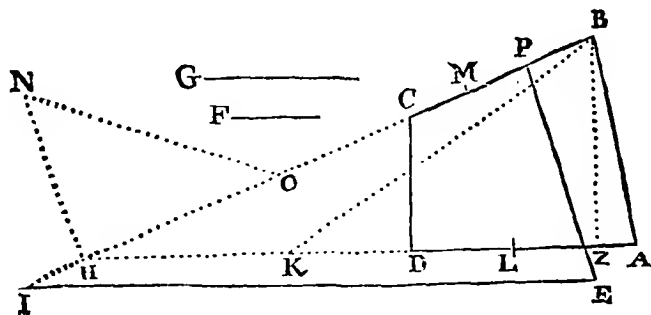


First, draw the line HK dividing the Plot into two parts, namely, into the five sided figure ABCFG, and into the Trapezia, FCDE, then (*by the 31. Probleme*) reduce the five sided figure ABCFG into the Triangle HAK, the base whereof HK divide into two equal parts in O, and draw the line OA, which shall divide the five sided figure ABCFG into two equal parts. Then (*by the 30th. Probleme*) reduce the Trapezia FCDE into the Triangle OLM, and divide the base thereof LM into two equal parts in the point P, and draw the line OP, which will divide the Trapezia FCDE into two equal parts by the lines AO and OP, but to perform the Probleme by one right line only, do thus, from the point A, draw the line AP, and parallel thereunto, through the point O, draw the line ON. Lastly, if you draw a right line from A to N, it shall divide the whole Plot into two equal parts.

☛ Here note that whatsoever hath been said concerning the dividing of figures in proportion to right lines, the same may be effected in numbers, so that from any Plot you may cut off any number of Acres, Roods, or Perches.

PROB. XLI.

How to divide a Trapezia into two parts by a line drawn from a point without, which parts shall be in proportion one to the other, as two given lines.



Let the Trapezia given be ABCD, and let the given point without be E, from which it is required to draw a line which shall divide the Trapezia into two parts which shall be in proportion one to the other, as the line F is to the line G.

Extend the sides of the Trapezia BC and AD till they concur in H, then through the point E draw the line EI parallel to AH, till it meet with the line BH being extended to I, then (*by the 29 Probleme*) reduce the Trapezia ABCD into the Triangle ABK, and from the point B let fall the perpendicular BZ, then (*by the 13th. Probleme*) divide the base of the Triangle AK into two parts in proportion as F to G, which point of Division will fall in L. This done (*by the 11th. Probleme*) find a fourth line which shall be in proportion to the three lines *i.e.* HL, and HB, that is, as IE : to HL :: so HB : to HM, so is HM the fourth proportional : then (*by the 24th. Probleme*) find a mean proportional between the lines IH, HM, which is HN, then set HN perpendicular upon BH, and divide HM into two equal parts in O, then draw the line ON, which you shall set from O to P. Lastly, if you draw the line EP, it shall divide the Trapezia ABCD in two parts, which shall be in proportion one to the other, as the line F is to the line G.

The end of the first Book.



THE COMPLEAT SURVEYOR:

The Second Book.

THE ARGUMENT.



IN this *Book* is contained both a general and particular description of all the most necessary *Instruments* belonging to *Surveying*, as the *Theodolite*, *Circumferentor*, and *Plain Table*, with all the appurtenances thereunto belonging, as the *Staff*, *Sockets*, *Screws*, *Index*, *Label*, and other necessities. Now, whereas these three *Instruments* are the most convenient for all manner of practices in *Surveying*, I have so ordered the matter, that in this *Book*, after the *Theodolite*, and *Circumferentor* are particularly described, as they have usually been made; I come to the description of the *Plain Table*, and therein have

have shewed how that *Instrument* may be ordered to perform the work of any of the other; so that whatsoever may be done by the *Theodolite*, *Circumferentor*, or any other *Instrument* the same may be effected by the *Plain Table* onely, as it is there contrived, with the same ease, dispatch, and exactness, and in many respects better, as in *Chapter I.* doth plainly appear: so that this *Instrument* onely is sufficient for all manner of practices whatsoever. And besides the fore-mentioned *Instruments* for *Mensuration* there is described divers other *Instruments* belonging therunto, as *Chains*, *Scales*, *Protractors*, and the like; all which are described according to the best contrivance yet known. Vnto these *Instruments* I have (in this second Edition) added the description and use of another *Instrument* very portable; the which will perform with exactness all the uses that can be effected, either by *Circumferentor*, *Semicircle*, *Theodolite*, or *Perætor*.

A



A
DESCRIPTION
OF
INSTRUMENTS.

CHAP. I.

Of INSTRUMENTS in general.



He particular description of the several Instruments that have from time to time been invented for the practice of Surveying, would make a Treatise of it self, and in this place is not so necessary to be insisted on, every of the Inventors, in their construction. To omit therefore the description of the *Topographical Instrument* of Mr. Leonard Digges, the *Familiar Staff* of Mr. John Blagrove, the *Geodetical Staff* and *Topographical Glass* of Mr. Arthur Hopton, with divers other Instruments invented & published by *Gemma Frisius*, *Orontius*, *Clavius*, *Stoflerus*, and others; I shall immediately begin with the description of those which are the ground and foundation of all the rest, and are now the only Instruments in most esteem amongst Surveyors, and those are chiefly these three, the *Theodolite*, the *Circumferentor*, and the *Plain Table*. Now, as I would not confine any man to the use of one particular *Instrument* for all employments, so I would advise any man not to cumber himself with multiplicity, since these three last named are sufficient for all occasions. And if I should confine any man to the use of any of these Instruments (as, for a shift, any one of them will perform any kind of work in Surveying) yet in that I should do him injury, for in many cases one Instrument may make a quicker dispatch, and be altogether as exact as another: As in laying down of a spacious business, I would

a advise him to use the *Circumferenter* or *Theodolite*, and for Townships and small Inclosures the *Plain Table*, to altering his Instrument according as the nature or quality of the ground he is to measure doth require.

These three special Instruments have been largely described already by divers, as namely, by Mr. Diggs, Mr. Hopton, Mr. Rashburn, and I list of all in *Planimetria*; yet in this place it will be very necessary to give a particular description of them again, because if any man have a desire to any particular Instrument, he may give the better directions for the making thereof.

For the description which I shall make of these three Instruments in particular, it shall be agreeable to those Instruments as they are usually made; with some small addition or alteration: But when I come to the description of the *Plain Table*, after that I have described it according to the vulgar way, I will then shew you a new *metamorphosis* of that Instrument, making it the most absolute and universal Instrument yet ever invented, so that having that one Instrument (made according to the following directions) you shall have need of no other for the due, exact, and speedy performance of any thing belonging to the Art of Surveying. For, the frame of the Table being graduated according to that description, will be an absolute *Theodolite*, and perform the work thereof with the same facility and exactness, and whatsoever may be done by the limbe of the *Theodolite*, the same the degrees on the frame of the Table will as well perform.

Likewise, the Index and Sights, together with the Box and *Recess* being taken from the Table, and screwed to the Staffe (as in the description thereof it is so conveniently ordered) will be an absolute *Circumferentor*, and in some respects better then the ordinary one hereafter described, because the Sights thereof stand at a greater distance, so that thereby the visual line may be the better directed.

And this Instrument (as now contrived) though it be called the *Plain Table* only, yet you see that it contains both the other, and therefore in advising any man to the use thereof chiefly, I do not confine him to one, but to all Instruments, and therefore do not contradict my former expression.

Besides, there is another great convenience which doth ensue by the degrees on the Tables frame; for in taking the plot of a field according to the following directions by the *Plain Table*, you may at the same time perform the same work by the degrees on the frame of the Table, if at the drawing of every line you observe the degrees cut by the Index, and note them upon the paper. This I say is a great convenience, for at one observation you perform two works with the same labour, as in the uses of these Instruments severally a Surveyor by this contrivance, which with practise will appear of themselves.

The Plain
Table used
as the
Theodolite.

The Plain
Table used
as a Circumferentor.

The Plain
Table, not
one, but all
Instruments.

CHAP. II.

Of the Theodolite, the description thereof, and the detection of an error frequently committed in the making thereof, with the manner how to correct the same.



The *Theodolite* is an Instrument consisting of Four parts principally. The first whereof is a Circle divided into 360 equal parts, called degrees, and each degree sub-divided into as many other equal parts as the largeness of the Instrument will best permit: For the diameter of this Circle, it may be of any length, but those usually made in brass are about twelve or fourteen Inches, and the limbe thereof divided as aforesaid into 360 degrees, and sub-divided into other parts by diagonal lines drawn from the outmost and inmost concentric Circles of the limbe; in the drawing of which concentric Circles, they use to draw them equidistant, which is erroneous, as shall appear hereafter.

The second part of this Instrument is the Geometrical Square; which is described within the Circle, and the sides thereof divided into certain equal parts, but there are few of them made now with this Square, for the degrees themselves will better supply that want, it being only for taking of heights and distances. Yet if any man be desirous to have this Square upon his Instrument; there is a more convenient way to set it on then that which Master *Diggs* sheweth, namely, upon the limbe of the Instrument, the manner how is very well known to the Instrument maker.

The third part of this Instrument is the Box and Needle, so conveniently contrived to stand upon the Center of the Circle, upon which Center also the Index of the Instrument must turn about; and sometimes over the Box and Needle there is a Quadrant erected for the taking of heights and distances.

The fourth part of this Instrument, to set it upon a staff when you make use thereof. In the making of this Instrument, it were necessary to have two back-sights fixed at each end of one of the Diameters, for the readier laying out of any angle without moving of the Instrument.

CHAP. III.

The description of the Circumferentor.

His Instrument hath been much esteemed by many, for portability thereof, it being usually made to contain in length about eight inches, in breadth 4 inches, and in thickness about three quarters of an inch; one side whereof is divided into divers equal parts, most fitly of ten or twelve in an inch; so that it may be used as the Scale of a *Protractor*, the Instrument it self being fitting to protract the plot on paper by help of the Needle, and the degrees of angles, and length of lines taken in the field. On the upper side of this Instrument is turned a round hole, three inches, and a half Diameter; and about half an inch deep, in which is placed a Card divided commonly into 120 equal parts or degrees, and each of those into three, which makes 360 answerable to the degrees of the *Theodolite*, in which Card is also a Dial drawn to find the hour of the day, and Azimuth of the Sun; within the Box, is hanged a Needle touched with a Load-stone, and covered over with a clear glass to preserve it from the weather.


On the upper part of this Instrument is also described a Table of natural Sines, collected answerable to the Card in the box, that is to say, if the Card be divided but into 120 parts, the Sines must be so also; but if into 360, the Sines must be the absolute degrees of the Quadrant.

To this Instrument also belongeth two Sights, one double in length to the other, the longest containing about seven inches, being placed and divided in all respects, as those hereafter mentioned in the description of the Plain Table. On the edge of the shorter sight toward the upper part thereof, is placed a small wyer representing the Center of a supposed Circle, the Semidiameter whereof is the distance from the Wyer to the edge of the Instrument underneath the same, which parts is imaginarily divided into sixty equal parts, and according to those divisions is the right line of divisions on the edge of the Instrument divided, and numbred by 5, 10, 15, from the perpendicular point to the end thereof: And also from the same point on the upper edge of the Instrument is perfected the degrees of the Quadrant, supplying the residue of those which could not be expressed on the long sight, from 28 to 90 by tens.

There is also belonging to these divisions a little Ruler, at one end whereof is a little hole to put it upon the wyer, on the edge of the shorter sight; and at the other end of this Ruler is placed a small sight, directly over the fiducial edge thereof; which edge is likewise divided according to those divisions on the edge of the Instrument. To this short sight is added a plummet to set the Instrument horizontal. And this short Ruler, with the divisions thereof, and those on the edge of the Instrument serve for taking of altitudes chiefly, and for the reducing of Hypothennsal to Horizontal lines.

CHAP. IV.

A Description of the Plain Table, how it hath been formerly made, and how it is now altered, it being the most absolute Instrument of any other for a Surveyor to use, in that it performeth whatsoever may be done either by the Theodolite, Circumferentor, or any other Instrument, with the same ease and exactness.

 The Table it self is a Parallelogram, containing in length about fourteen inches and a half, & in breadth eleven inches: it is composed of three several boards, which may be taken asunder, for ease and convenience in carriage. For the binding of these three boards fast when the Table is set together, there belongeth a joynted frame, so contrived, that it may be taken off, and put on the Table at pleasure: this frame also is to fasten a sheet of paper upon the Table, when you are to describe the plot of any field, or other inclosure by the Table. This frame must have upon it, neer the inward ledge, Scales of equal parts on both sides, for the speedy drawing of parallel lines upon the paper; and also for the shifting of your paper, when one sheet will not hold your whole work.

Unto this Table belongeth a Ruler or Index, containing in length about sixteen Inches or more, it being full as long as from angle to angle of your Table; it ought to be about two inches in breadth, and one third part of an Inch in thickness. Upon this Ruler or Index two sights must be placed; one whereof is double in length to the other, the longer containing in length about twelve inches, the other six: on the top of this shorter sight is placed a brasse pin, and also a thrid and plummet to place your Instrument horizontal. Through the longer sight must be made a slit, almost the whole length thereof, These two sights thus prepared, are to be perpendicularly erected upon the Index; in such sort, that the wyer on the top of the shorter sight, and the slit on the longer sight stand precisely over the fiducial edge of the Index. The space or distance of these two sights one from the other, is to be equal to the divided part of the longer sight. Upon the longer sight is to be placed a Vane of brasse, to be moved up and down at pleasure, through which a small hole is to be made, answerable to the slit in the same sight, and the edge of the Vane.

By these sights thus placed on the Index there is projected the Geometrical Square, whose side is the divided part of the long sight (or the distance between the two sights.) In the middle of the

the long sight (through the whole breadth thereof there is drawn a line called the line of Level, dividing the side of the projected Square into two equal parts: also the same side is on this sight divided into a hundred equal parts, which are numbered upwards and downwards, from the line of Level, by fives and tens to fifty, on either side, which divisions are called the Scale.

There is also on the same sight another sort of division, representing the hypotenusal Lines of the same Square, as they increase by Unites, and are likewise numbered upwards and downwards from the line of Level, from one to twelve, by 1, 2, 3, &c. sometimes signifying 101, 102, 103, &c. these divisions shew how much any hypotenusal or slope line drawn over the same Square. exceedeth the direct horizontal line, being the side of the same Square

On this sight there is a third sort of divisions, representing the degrees of a Quadrant (or as many as the same sight is capable to receive, which are about 25) numbered from the line of Level upward and downward by fives and tens to 25, which divisions are called the Quadrant.

Unto this Instrument, as unto all others belong these necessary parts as the Socket, the Staffe, the Box, and Needle, &c.

☛ According to this description, have Plain Tables formerly been made, but if unto it be added these additional parts & alterations (which make it lesse cumbersome then before) it will be the most exact, absolute and universal Instrument for a Surveyour that was ever yet invented.

First, Let the frame be so fitted to the Table; that it may go on easily, either side being upwards; so that as one side is divided into equal parts (as in the description the other side may have projected upon it the 180 degrees of a Semicircle, from a Center noted in the superficies of the Table, which degrees must be numbered from the left hand towards the right (when the Center is next to you) by fives and tens to 180, and then beginning again, set 190, and so successively to 360. These degrees thus inserted are of excellent use in wet or stormy weather, when you cannot keep a sheet of paper upon your Table, either in respect of rain or winde. Also these degrees will make the Plain Table to be an absolute Theodolite so that you may work with these degrees as if they were the degrees of a Theodolite.

Secondly, Upon the Index or Ruler before spoken of, (instead of the sights before described) let there be placed two sights, both of one length, and back-sighted; one having a slit below, and a thrid above; and the other, a slit above, and a thrid below, serving to look backward and forward at pleasure without turning about the Instrument, when the Needle is at quiet. The expedition that these back-sights will make, will best appeare by practice; for using these you shall need (in going about a field) to plant your Instrument but at every second angle.

Thirdly,

Thirdly, for the ready taking of heights, and the reducing of Hypothenusal to Horizontal lines (instead of the divisions on the sights before mentioned) let there be projected a Tangent line along the side of the Ruler, whose divisions must touch the very edge thereof, so that a Label or Ruler of Box or Brasse, which is hanged on a pin sticking in the side of one of the back-sights, and having another small sight at the end thereof, may move justly along the side of the Index; then (the Instrument standing horizontal) if you look through this small sight, and by the Pin on which the Label hangereth, moving the Label too and fro, till you espie the mark you look at, then will the Label shew you what Degree of the Tangent line is cut thereby. This on line thus projected upon the side of the Ruler performeth all the uses of those divided sights and is far better, and lesse cumbersome then them or a Quadrant (such as I formerly described in *Planimetria* because the degrees are larger. This line of Tangents is projected on the Index from the foot of the fathermost sight, all along the Ruler to the foot of the nethermost sight, and up the side thereof and is numbered from 1 to 90, by 10, 20, 30, 40, 50, &c. ending at the foot of the furthermost sight; from whence the line proceeded.

The use of this line of Tangents in taking of Heights is shewed in the fourth Book, and is used with the Tables of Sines and Logarithms created of in the third Book, without which Tables, (of something equivalent thereunto) this line of Tangents will be of little use; therefore it will be convenient to have upon the Index of your Table the lines of Artificial Numbers, Sines, and Tangents, by which you may work any proportion required very speedily and exactly, so that if you be destitute of your Tables, these Lines will sufficiently help you.

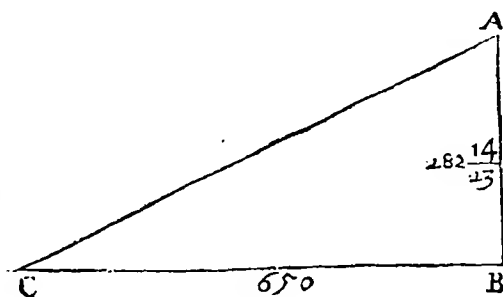
There is yet another way by which you may take any altitude, or reduce Hypothenusal to Horizontal lines, only by Vulger Arithmetick, without the help of Tables, by having a line of equal parts divided on the edge of the Index, and another line of the same equal parts on the Label, by which lines, and Vulgar Arithmetick, an Altitude may very well be taken.

Now because I intend only to shew in general the use of these equal parts, I will therefore do it in this place, because I shall have occasion to speake no more thereof hereafter: The use thereof (briefely) is thus.

Suppose that the line AB were some Hill or Tower, whose Altitude you require; standing at C, and looking through the sights in your Label till you espie the top of the Tower at A, there finde the Label to cut 230 of the equal parts; then measuring the distance from your station at C, to the foot of the Tower at B, you finde it to contain 650 foot, then to finde the altitude AB, say,

As

As 230, the parts cut by the Label,
Is to 100;
So is 650, the measured distance C B,
To $282\frac{14}{25}$, for the altitude A B.



Therefore, multiply 650 by 100, and divide that Product by 230, the Quotient will be $282\frac{14}{25}$, for the altitude A B.

Now for the reducing of Hypothenuſal to Horizontal lines, having measured the Hypothenuſal line with your Chain, the proportion will be :

As the equal parts cut on the Label,
Are to the equal parts cut on the Index ;
So is the length of the Hypothenuſal line measured,
To the length of the Hypothenuſal line required.

I thought good to give the Reader a view of the ſeveral ways there are to perform theſe concluſions, leaving every man at liberty to uſe that which he beſt liketh, or all if he pleaſe, for all the lines may very well be put upon one Inſtrument without any confuſion of lines : but the way which I ſhall chiefly inſiſt upon in the proſecuting of this Work, ſhall be by the line of Tangents, as being (in my opinion) the beſt of all. Now when I come to ſhew you the uſe of this line of Tangents, with the Tables of Sines and Logarithms in the reſolving of Triangles, I will alſo ſhew you how to perform the ſame Propoſitions by the lines of Artificial Numbers, Sines, and Tangents, and therefore I would adviſe every man to have theſe ſo neceſſary lines upon his Index alſo.

Fourthly, Unto this Inſtrument alſo belongeth a Box and Needle, which is to be faſtened to the ſide of the Table by help of two ſcrews, ſo that it may be taken off and put on at pleaſure. In the bottom of this Box muſt be placed a Card divided into 360 degrees numbred (if you pleaſe) after the uſual manner, from the North Eaſtward, but the Card by which all the Examples in this Book were

were framed was numbered from the North Westward by 10, 20, 30, &c. to 360, contrary to the common custome.

There belongeth also to this Instrument a Socket of Brasse to be screwed on the back side of the Table, into which must be put the head of the three legg'd Staff, this Staff ought to be joynted in the middle, so that it may be the more portable For the Socket it may be a plain one, but a Ball and Socket with an endless screw is the best of all, for by help thereof you may place the Table (or any other Instrument) either Horizontall, Verticall, or in any other position.

☞ Note, that this Instrument (if made according to these directions) is the most absolute Instrument for a Surveyor to use.



CHAP. V.

The description of an Instrument which will perform the work of the Theodolite or Circumferentor, but especially of the Peractor, with great ease and exactness, and for portability exceedeth any of the forementioned.



He Instrument consisteth of a rectangled *Parallelepipedon*, of what length, breadth and depth you please, but a convenient length will be about 15 or 16 Inches, the breadth about 3 Inches, and the depth about one Inch. On one of the broader Superficies, and in the middle thereof, let there be cut out a little narrow Box about an Inch and half broad, and in length according to the length you intend your Needle, in the middle of this Box let there be drawn a Meridian line marked with a *Flowre-de-luce* for the North point, by this means you may have your Needle longer then in the comon *Circumferentor*, before described; upon the same side of the broader superficies of this *Parallelepipedon*, let there be at each end thereof, cut two other places in which to lay the Sights when they are taken out of the Index for convenience in carriage, so the Sights being laid therein, will be preserved and lie in a little room.

On one of the narrower sides of the said *Parallelepipedon*, within three quarters of an Inch of the extream ends thereof, let there be made to Mortizes about halfe an Inch square, and about an Inch deep.

Then prepare a joynted frame consisting of three sides, such as the frame of a Plain Table to fold in, that it may lie in a little room, one of which sides must be as long as both the other, so that being folded together, it lie upon the former *Parallelepipedon*. The two shorter ends of this frame (when you use the Instrument in the

field) must be put into the two former Mortizes, to a certain distance, and there fixed with two screws, so will the frame represent a rectangled Parallelogram, the three sides of this frame must be divided in all respects as the frame of a Plain Table, by divisions transferred. And if you please, you may have the other side divided into two quadrants, each divided into 90 degrees, from 00 to 90, and from 90 to 00, so may you by this means make the instrument capable of performing the uses of a Card divided into 4 nineties, for the North-east, South-west, North-east, & South-east Quarters of the Heavens, which degrees in this case will be very large, and effect that manner of work with more exactness then by a smaller Card.

¶ Here note, that in the description of the former Instruments, that when I mention a Card, every man is at liberty to have what Card liketh him best, as a Card of 360 degrees, or 120 parts, or into four nineties, according as Master Norwood adviseth; but in my opinion, a Card which hath all these Divisions is the most absolute, and this may very easily be done without confusion, if three Circles be made concentrick, for one and the same divisions will very well serve for the 360 degrees, and the four nineties, and the innermost for the 120 parts, and to avoid mistakes it will not be amiss to have the middlemost concentrick Circle to be coloured with some distinct transparent colour, or numbred with red figures.

Unto this Instrument there also belongeth an Index and Sights, and if you make two Mortizes in the extreame ends of the *Parallelepipedon*, wherein to set the sights, and cause a Tangent line to be drawn by the edge of the *Parallelepipedon*, the Instrument (with a Label) will be very commodious for the taking of heights.

This Instrument being thus made, and set upon a Staff, will be very convenient for all purposes.



CHAP. VI.

The description of an Instrument called a Cross.



His Instrument is of good use in small inclosures of many sides, the use whereof shall be shewed hereafter in the fourth Book.

It is only two Rulers of Wood, in length about 14 Inches, crossing one the other in the midst at right angles, and having at each end of both the Rulers back-sights, which serves only to set out right angles in the field it self.

CHAP. VII.

Of Chains, the several sorts thereof.



F Chains there are divers sorts, as namely, Foot Chains, each link containing a Foot or 12 Inches, and so the whole Pole or Perch will contain $16\frac{1}{2}$ Links or Feet, answering to the Statute denomination.

Some Chains have each Pole divided into ten equal parts, and these are called Decimal Chains, and this gross division may be convenient in some practises.

The Chain now used, and most esteemed amongst Surveyors, are especially two, namely, that generally used by Master *Rathborn* which hath every Perch divided into 100 Links, and that of Master *Gunter* which hath four Poles divided into 100 Links, so that each Link of Master *Gunter's* Chain is as long as four of Master *Rathborn's*.

Now because these Chains are most esteemed of and used by Surveyors, I will therefore make a general description of them both, leaving every man at liberty to take his choice.

Of Master *Rathborn's* Chain.

THe Chain which Mr. *Rathborn* ordinarily used (as himself saith) contained in length two Statute Poles or Perches, each Pole containing in length $16\frac{1}{2}$ feet, which is 198 Inches, then each Pole was divided into 10 equal parts called *Primes*, every of which contained in length $19\frac{1}{2}$ Inches; again, every of those *Primes* was sub-divided into 10 other equal parts called *Seconds* so that every of these *Seconds* contained in length $1\frac{1}{2}$ Inch, so that the whole Pole, Perch, Unite, or Commencement (as he calleth it) was divided into 130 equal parts or Links called *Seconds*.

The Chain (or one Pole thereof) being thus divided, at the end of every 50 Links or half Pole, let a large Curtain ring be fastned so shall you have in a whole Chain of two Perches long, three of these Rings, the middle most being the division of the two Poles. Then at the end of every *Prime*, that is at the end of every ten Links let a smaller Curtaine Ring be fastened.

By this distinction of Rings, the Chain is divided into these three denominations *Unites*, *Primes*, and *Seconds* whose Characters are these... so that if you would expresse $4\frac{1}{2}$ *Unites*, 8 *primes* and 7 *Seconds*, they are thus to be written, 4087, by which you may perceive that those Figures which have no pricks over them are *Unites* or *Integers*, and the figure under the first point *Primes*, and under the next *Seconds*; so also, three *Unites*, seven *Primes*, and two *Seconds*, will stand thus, 378.

Besides these divisions Master *Rathborn* for his own use, sewed at the end of every two *Primes* and a halfe (which is a quarter of a Pole) a small red cloth, and at every seven *Primes* and a halfe (being three quarters of a Pole) the like of yellow: or other discernable colour, which much helped him in the ready reckoning of the several Rings upon the Chain, remembering this Rule: That if it be the next Ring short of the Red, it is two *Primes*; if the next over, three; if the next short of the yellow seven *Primes* if the next over eight; if the next short of the great halfe Ring it is four, the next over six: and if the next short of the middle great Ring, it is nine, and if the next over one.

☛ But here is to be noted, that if you use this distinction by colours, you must alwayes work with one end of the Chain from you.

This Chain being thus divided and marked, you have every whole Pole equal to ten *Primes*, or 100 *Seconds*: every three quarters of a Pole equal to seven *Primes* and a half, or 75 *Seconds*: every half Pole equal to five *Primes*, or 50 *Seconds*: and lastly, every quarter of a Pole equal to two *Primes* and a halfe, or 25 *Seconds*.

And here is to be noted, that in the ordinary use of this Chain, for measuring and platting, you need take notice only of *Unites* and *Primes*, which is exact enough for ordinary use, but in case that separation or division of Lands into several parts, you may make use of *Seconds*.

Of Master *Gunters* Chain.

As every Pole of Master *Rathborns* Chain was divided into the Links, so Master *Gunters* whole Chain (which is alwayes made to contain four Poles) is divided into 100 Links one of these Links being four times the length of the other. Now if this Chain be made according to the Statute, each Perch to contain 16½ Feet, then each Link of this Chain will contain 7 Inches, and $\frac{1}{16}$ of an Inch, and the whole Chain 729 Inches, or 68 Foot.

In measuring with this Chain, you are to take notice only a Chains and Links, as saying such a line measured by the Chain contains 72 Chain, 43 Links, which you may expresse more briefly thus, 7348, and these are all the Denominations which are necessary to be taken notice of in Surveying of Land.

For the ready counting of the Links of this Chain, there ought to be these distinctions namely, In the middle thereof, which is at two Poles end, let there be hanged a large Ring, or rather a plate of brasse like a Rhombus, so is the whole Chain (by this plate) divided into two equal parts.

Secondly, Let each of these two parts be divided into two other equal parts by smaller Rings or Circular plates of brasse, so shall the whole Chain be divided into four equal Parts or Perches, each Perch containing 25 Links.

Thirdly, At every ten Links let be fastened a lesser Ring then the former, or else a Plate of some other fashion, as a Semicircle or the like. And lastly, at every fift link (if you please) may be fastened other marks, so by this means you shall most easily and exactly count the Links of your Chain without any trouble. The Chain being thus distinguished, it mattereth not which end thereof be carried forward, because the notes of distinction proceed alike on both sides from the middle of the Chain.

¶ Here note, that in all the examples in this Book, the lines are supposed to be measured by this four Pole Chain of Master Gunter, it being the best of any other: the manner how to cast up the content of any plot measured therewith, shall be hereafter taught in its due place.

Cautions to be observed in the use of any Chain.

IN measuring a large distance with your Chain, you may casually mistake or misse a Chain or two in keeping your account, from whence will ensue a considerable error: Also in measuring of distances (when you go not a long by a hedge side) you can hardly keepe your Instrument, Chain and Marke, in-right line, which if you do not, must necessarily make your measured distance greater then in reality it is. For the avoyding of either of these mistakes, you ought to provide ten small sticks or arrows, which let him that leadeth the Chain carry in his hand before, and at the end of every Chaine, stick on of these Arrows into the ground, which let him that followeth the Chain take up, so going on till the whole number of Arrows be spent and then you may conclude that you have measured ten Chains without any further trouble, and these ten Chains (if the distance you are to measure be large) you may call a Change, and so you may denominate every large distance by Changes, Chains and Links. Or you may at the end of every ten Chains set up another kind of stick, by which (standing at the Instrument) you may see whether your eye, the stick, and the Mark to which you are to measure be in a right line or not, and accordingly guide those that carry the Chain, with the more exactnesse to direct it to the Mark intended.

How

How to reduce any number of *Chains* and *Links*, into *Feet*.

IN the practice of many Geometrical Conclusions, as in the taking of Heights and Distances, hereafter taught, it is requisite to give your measure (in such cases) in Feet or Yards, and not in Poles or Perches; yet because your Chain is the most necessary Instrument to measure withal, I thought it convenient in this place to shew you how to reduce any number of Chains and Links into Feet, which is thus.

Multiply your number of Chains and Links together as one whole number, by 66, cutting off from the product the two last figures towards the right hand, so shall the rest of the product be Feet, and the two figures cut off shall be hundred parts of a Foot.

EXAMPLE.

Let it be required to know how many Feet are contained in five Chains, 32 Links. First, Set down your five Chains, 32 Links as is before taught, and as you see in the first Example, with a Comma between the Chains and Links, then multiplying this five Chains, 32 Links by 66, the product will be 35112, from which, cut off the two last figures toward the right hand with a Comma, then will the number be 351,12, which is 351 Feet and $\frac{12}{100}$ parts of a foot, and so many Feet are contained in five Chains, 32 Links.

Example I.

$$\begin{array}{r} 5,32 \\ 66 \\ \hline 3192 \\ 3192 \\ \hline 351,12 \end{array}$$

Example II.

$$\begin{array}{r} 9,05 \\ 66 \\ \hline 5430 \\ 5430 \\ \hline 597,30 \end{array}$$

But let the number of Chains be what they will, if the number of Links be less than 10, as in the second Example it is nine Chains five Links, you must place a Cypher before the five Links as there you see, and then multiplying that number (*viz.* 9,05) by 66, the product will be 59730 from which taking the two last figures there will remain 597 Feet, and $\frac{30}{100}$ parts of a Foot. The like may be done for any other number of Chains and Links whatsoever.

According to these Examples is made the Table following, which sheweth how many Feet are contained in any number of Chains Links from five Links to eight Chains, for every fifth Link, which is sufficient for ordinary use, by which Table you may see that in six Chains 40 Links, is contained 421 Feet, and $\frac{10}{100}$ of a Foot, Also in five Chains 55 Links is contained 366 Feet: and $\frac{10}{100}$ parts of a Foot: and so of any other.

**A Table shewing how many Feet, and parts of
a Foot are contained in any number of Chains and Links
between five Links and eight Chains.**

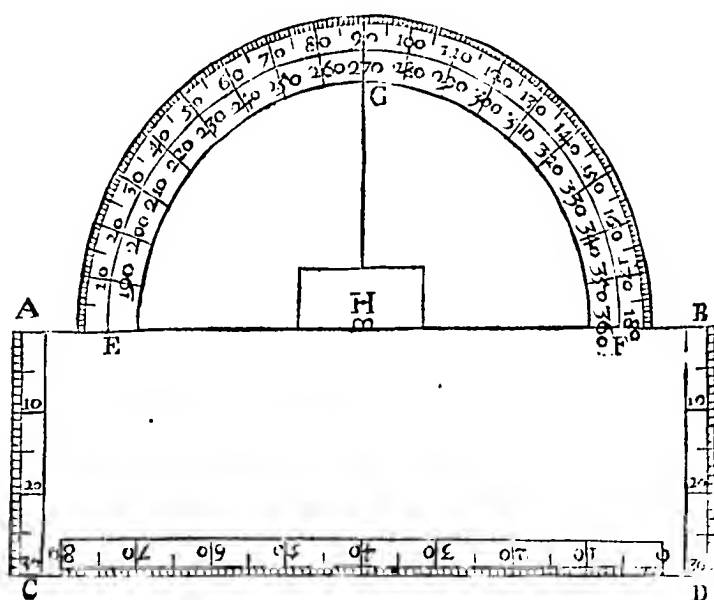
	0	1	2	3	4	5	6	7
0		66,00	132,00	198,00	264,00	330,00	396,00	462,00
5	3,30	96,30	135,30	201,30	267,30	333,30	399,30	465,30
10	6,60	72,60	138,60	204,60	270,60	336,60	402,60	468,60
15	9,90	75,90	141,90	207,90	273,90	339,90	405,90	471,90
20	13,20	79,20	145,20	211,20	277,20	343,20	409,20	475,20
25	16,50	82,50	148,50	214,50	280,50	346,50	412,50	478,50
30	19,80	85,80	151,80	217,80	283,80	349,80	415,80	481,80
35	23,10	89,10	155,10	221,10	287,10	353,10	419,10	485,10
40	26,40	92,40	158,40	224,40	290,40	356,40	422,40	488,40
45	29,70	95,70	161,70	227,70	293,70	359,70	425,70	491,70
50	33,00	99,00	165,00	231,00	297,00	363,00	429,00	495,00
55	36,30	102,30	168,30	234,30	300,30	366,30	432,30	498,30
60	39,60	105,60	171,60	237,60	303,60	369,60	435,60	501,60
65	42,90	108,90	174,90	240,90	306,90	372,90	438,90	504,90
70	46,20	112,20	178,20	244,20	310,20	376,20	442,20	508,20
75	49,50	115,50	181,50	247,50	313,50	379,50	445,50	511,50
80	52,80	118,80	184,80	250,80	316,80	382,80	448,80	514,80
85	56,10	122,10	188,10	254,10	320,10	386,10	452,10	518,10
90	59,40	125,40	191,40	257,40	323,40	389,40	455,40	521,40
95	62,70	128,70	194,70	260,70	326,70	392,70	458,70	524,70

CHAP. VIII.

Of the Protractor.



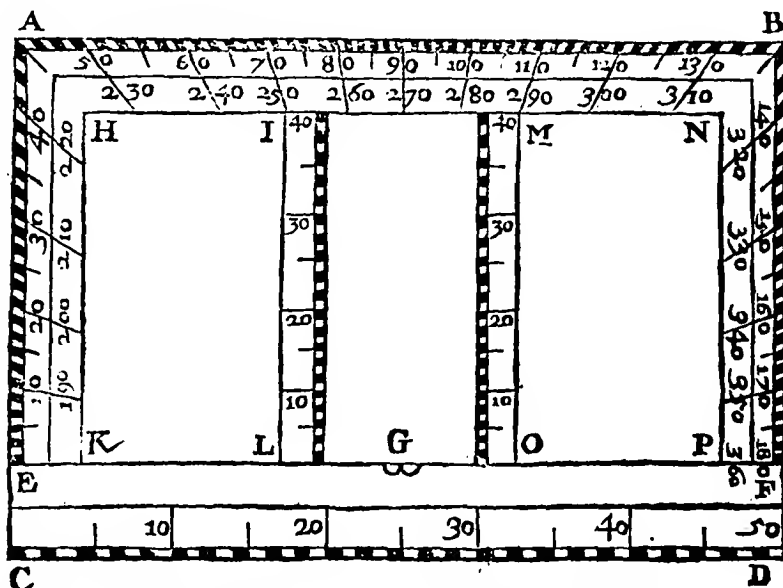
Protractor is an Instrument by which you may protract or lay down upon paper or otherwise, the true symmetry or proportion of any field, having made observation of the sides and angles thereof by some of the Instruments before described. This Instrument consisteth of two parts, the one is a Semicircle divided into degrees, as is the frame of the Table, and the other is a Scale divided into equal parts, the Semicircle being to lay down the angles, and the Scale to plot the sides. This Instrument ought to be made of a piece of thin brass well polished, the edges thereof being very smooth, and the Scale thereof, namely, the right angled Parallelogram, or long square containing in length from A to B about four Inches and three quarters, and in breadth from A to C about one and a half. Let the two ends of the Scale, namely, the sides, A C and B D be divided into equal parts of 16 or 20 in an Inch, and let the side C D be divided according to a Scale of 10 or 12 in an Inch.



The Scale being thus divided, on the middle of the line A B, as at H, describe the Semicircle EGF, which divide into two Quadrants in the point G, by help of the perpendicular HG: then divide each of those Quadrants into 90 equal parts called degrees, so shall the whole Semicircle contain 180 degrees, which must be numbered by 10, 20, 30, 40, &c. to 180, from E by G to F, and the same way also from 180 to 360, as you see done in the Figure, the numbers of the first Semicircle from 00 to 180 being for the East side of the Protractor, and the other numbers from 180 to 360 for the West side.

Now you are to note, that the line A B always representeth the Meridian line, and is sometimes noted with the letters S and N for South and North, but then it is necessary that the Protractor be divided on either side the plate, which this double numbering avoideth, for the line A B being taken for the Meridian in general, the Semicircle of the Protractor may be turned any way (either upward or downward) and so one Semicircle being divided will be sufficient; yet if any man be desirous, he may have it made according to his own fancy, but this manner of numbering (in my opinion) is the best, it being most agreeable to your Instruments.

G The Protractor here described is that which is commonly made and used, but this (the description whereof followeth) in my judgement was the best contrivance I have seen, the first whereof being made for my loving friend *Will. Forster* now in *Ireland* which is as followeth.



The Protractor consisteth of a piece of thin brasse in forme of a rectangled Parallelogram, upon which at the distance of halfe an inch draw the line *E F* parallel to *C D*, which line divide into two equal parts in the point *G* for the center, from which center let the sides *E A*, *A B*, and *B F* be divided by lines issuing from the center *G* into 180 degrees, and numbred by 10, 20, 30, 40, &c. to 180, and back again from 180 to 360, in all respects as the semicircle in the other Protractor was numbred.

Now because that in protracting (many times) the parallels will fall off of your paper or parchment so that you must adde a piece thereto for the present, there is in this Protractor, the Parallelogram *I M O L* cut quite out, that you may see your worke through, and either side of the narrow slip of brasse which is cut out, namely *I L* and *M O* must be divided into the same parts with the sides *E A* and *B F*, by a ruler laid from side to side, and these two sides must be numbred by 10, 20, 30, &c. as farre as they will extend.

To this Protractor (if you please) you may have added upon the edge *C D* a Scale of any equal part as of 10, 12, 20, 24, or 30 in an inch, this Protractor thus made, is very convenient for use and much exceedeth the other before described.

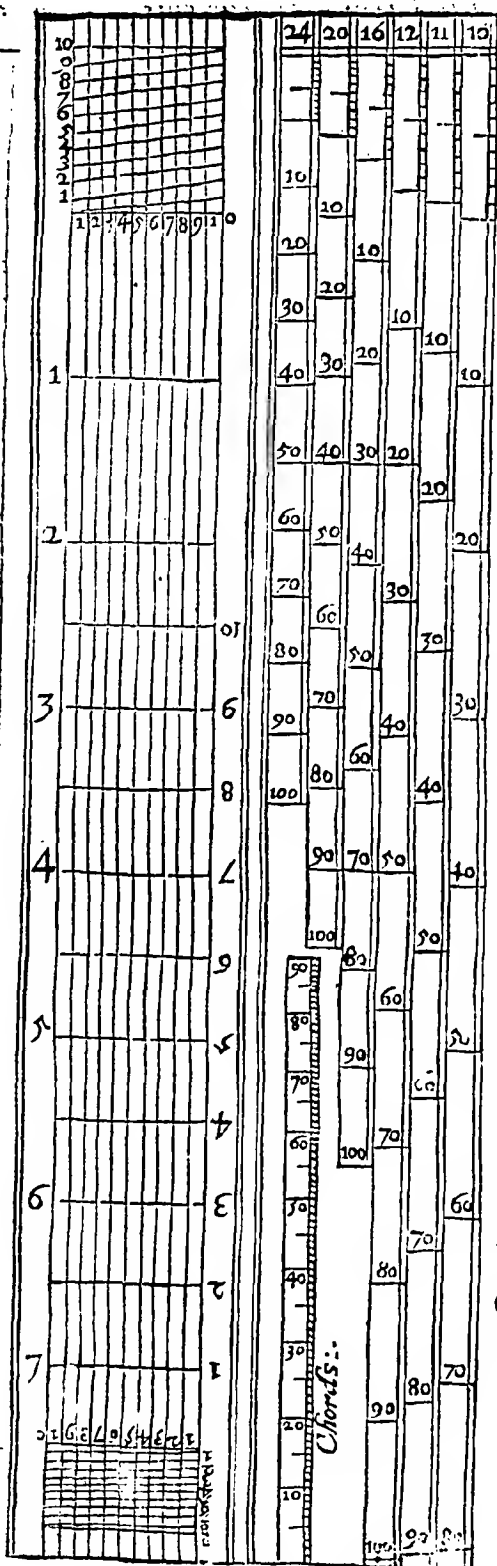
To use with your Protractor in protracting, you must provide a fine needle, put into a piece of Box or Ivory neatly turned, this will serve to fix in your center, note your degrees, and for other uses in drawing your Plot, and is called a Protracting pin.

CHAP. IX.

Of Scales.

Or the ready laying down of Lines and Arches according to any assigned quantity, you must provide divers Scales. The Scales now ordinarily used by Surveyors, are principally two: First, of equal parts, for the protracting of Lines: and Secondly, of Chords, for the protracting of Angles. Unto these may be added, Thirdly, a Diagonall Scal, which is (indeed) no other then a Scale of equall parts more scrupulously divided. If you desire a convenient Scale, let it be made in this manner, to contain in length about 8 or 9 Inches, and in breadth one Inch and a quarter: on one side thereof let be placed divers Scales, as of 10, 11, 12, 16, 20, 24, and 30 in an Inch.

¶ Here is to be noted, that when I say a Scale of 12 in an Inch, you are to understand a part of a line divided into 10 equall parts, 12 of which parts would make an



an Inch, and the like is to be understood of any other number of equal parts whatsoever.

On the same side of the Ruler let be placed a line of Chords extended up to 90, and numbred as you see in the figure by 10, 20, 30, &c. to 90. This Scale will be of good use for many purposes, as to divide the circumference of a circle, and to protract angles in some cases better then the Protractor.

On the other side of the Ruler let be drawn a Diagonal Scale, of 10 in an Inch, which will be an excellent Scale for large Plots, out of which you may very well take the hundred part of an Inch, and this Scale will agree with your four Pole Chain exceeding well, for as your whole Chain contains 100 Links, so each Inch of this Scale contains 100 parts, so that out of it you may take any number measured by your Chain, to a Link, and lay it down upon paper. You may also have half an Inch divided into 100 parts, which Scale will be of good use also to lay down a smaller Plot.

¶ But if you would have your Scales to be answerable to your Chain, and to agree with the divisions thereof, then you are to take notice that

$\begin{array}{c} 10 \\ 11 \\ 12 \\ 16 \\ 20 \\ 24 \\ 50 \end{array}$	Pole in an inch must be a Scale of	$\begin{array}{c} 10 \\ 11 \\ 12 \\ 16 \\ 20 \\ 24 \\ 30 \end{array}$	in 4 inches or	$\begin{array}{c} 2\frac{1}{2} \\ 2\frac{1}{4} \\ 3 \\ 4 \\ 5 \\ 6 \\ 7\frac{1}{2} \end{array}$	in one inch
A Scale of					

Then will each of those parts represent a Chain, and if you subdivide the last single part into ten, those parts shall represent links.

These Scales, also the lines of numbers Signes and Tangents, and reducing Scale hereafter mentioned, may very conveniently be placed on the Index of the plain Table.

To use with this Scale, you must provide a pair of neat Compasses of Brass, with steel points, filed very small, and also a neat pair of Compasses with three points, & Screws to alter the points, so that you may draw lines or Circles with black lead, or any coloured Inke, which will be very necessary and convenient in beautifying of your Plots after Protraction.

pose some distance measured to contain 16 Chains, 87 Links, the 16 Chains must be set in the third Column, and the 87 Links in the fourth Column, under their respective Titles, as you see here done.

¶ But if you use a Card of four nineties according to M. Norwood then your four Columns will represent the four Quarters of your Card, namely the South, North, East, and West, and then you must have two other Columnes also one for the degrees and minutes, the other for the lengths of lines, the manner whereof you shall see in the fourth Book when we come to examples,

CHAP. XI.

Of Instruments for Reducing of Plots.

H Or the reducing of Plots from one forme to another, there hath been divers Instruments invented. One that performeth that work very well, is a ruler having certain proportional Scales thereupon: with a sliding vein of brasse to move from end to end thereof, this Instrument well made and the lines thereupon fitted to your proportion, will be very easie and exact, the manner of using it and the way of proportioning of it, shall be shewed hereafter. This Instrument though it be not generall, yet it may easily be fitted to 5 or 6 severall proportions, which for that purpose is sufficient. The Scale of equal parts, which I described in *Planometria* being too particular I shall here reject. Another Instrument for the performance of this worke, is a Parallelogram, the making whereof is well known to the Instrument-maker.

The end of the second Book.





THE COMPLEAT SURVEYOR:

The Third Book.

THE ARGUMENT.



His third Book is as it were a Key to those that follow, the subject whereof is *Trigonometry*. Now forasmuch as the whole Art of measuring heights and distances, and plotting and protracting of Land, and all other lineall and superficial dimensions are grounded upon the resolution of *Plain Triangles*, I hold it convenient (before I come to the practice of Surveying or to shew the use of any Instrument in taking of heights & distances) to say something concerning *Plain Triangles* (at least so much as is necessary for a Surveyor to know) although that Subject be handled

handled by divers able *Mathematicians* already, whose *Works* are extant: viz. *Pitiscus*, *Snelius*, the Lord *Nepair*, Master *Gunter*, Master *Normood*, Master *Gellibrand*, &c. Now because the readiest way of resolving *Triangles* is by *Signes*, *Tangents*, and *Logarithms*, I have therefore added brief *Tables* for that purpose, viz. a *Table* of *Signes*, to every tenth minute of the *Quadrant*, and a *Table* of *Logarithmes* from 1, to 1000, omitting the *Table* of *Tangents*, partly because they are of little or no use in *Surveying*, and also because there are divers *Books* extant wherein they are at large, so that those who desire to make a further scrutiny into *Trigonometry*, may peruse the forementioned *Authours*. In this *Book* I have only insisted upon such *Cases* as may come in use in *Surveying*, and therefore have omitted divers, yet those which I have insisted on, are performed both by the *Tables* following in this *Book*, and also by the *Lines* of *Artificial Numbers*, *Sines* and *Tangents* before spoken of in the description of the *Index* of the *Plain Table* in the last *Book*.

TRI-



TRIGONOMETRIE.

CHAP. I.

The Explanation and Use of the Table of SINES.



Here I come to the mensuration of Triangles, it will be necessary to explain and shew the use of the Tables of *Sines* and *Logarithms* following, by which Tables the sides or angles of right lined Triangles may be readily and exactly measured, so that in any plain Triangle, if there be any three parts thereof given, a fourth may be easily discovered.

The Table of Sines consisteth of two Rows or Columns, the first whereof sheweth the Degrees and Minutes of the Quadrant, having over the head thereof these two letters, *D. M.* standing for Degrees and Minutes: In the second Column is the Artificial *Sines* answering to every Degree and 10th Minute of the Quadrant, having the word *Sine* over the head thereof. The use of this Table will appear by the following *Propositions*.

PROP. I.

Any Degree and Minute being given, to find the Sine thereof.

First, Seek the Degree and Minute in the first Column of the Table, under *D. M.* and right against it, in the next Column towards the right hand, under the word *Sine*, you shall have your degree.

K

EX.

EXAMPLE. I.

Suppose it were required to find the Sine of 20 degrees, First, you must seek 20 in the first Column of the Table under *D. M.* and right again 20 in the second Column under the word *Sine*, you shall find 9,534052, which is the Sine of 20 degrees.

In the same manner you shall find the Sine of 50 degrees to be 9,884254, and the Sine of 76 degrees to be 9,986904.

EXAMPLE. II.

Let it be required to find the Sine of 40 degrees, 30 minutes. First, you must find 40, 30 (which is 40 degrees 30 minutes) in the first Column, under the letters *D. M.* and against it you shall find 9,812544, which is the Sine of 40 degrees, 30 minutes.

Also the Sine of 62 degrees 10 minutes, will be found to be 9,946604, and the Sine of 86 degrees 30 minutes will be 9,999189, and in this manner may you find the artificial Sine of any number of degrees and minutes expressed in the Table.

PROP. II.

Any Sine being given, to find the number of degrees and minutes thereunto belonging.

EXAMPLE.

Let 9,866470 be a Sine given, and let it be required to find the degree and minute of the Quadrant answering thereunto. First, seek in the second Column amongst the Sines for 9,866470, and against it (on the left hand) you shall find 47 degrees 20 minutes, which is the arch of the Quadrant answering thereunto.

Again, Let it be required to find the arch answering to this Sine 9,821264, having found 9,821264 in the second Column under the word *Sine*, against it you shall find 41 degrees 30 min. and that is the arch or degree answering thereunto.

¶ But in case you have a number given which you cannot exactly find in the Table, you must then in stead thereof, take the nearest in the Table. As if your number given were 9,675859, if you look in the Table for this number it cannot be found there, but the nearest thereunto is 9,676328, which is the Sine of 28 degrees 20 minutes, which you must take instead thereof.

THE

The Table of Sines.

D. M.	Sines	D. M.	Sines	D. M.	Sines
0	0,000000	8	0,143555	16	0,2749358
10	7,463726	10	0,152451	18	0,3044720
20	7,764754	20	0,161164	20	0,3349054
30	7,940842	30	0,169702	30	0,3653342
40	8,065776	40	0,178072	40	0,3957584
50	8,162681	50	0,186280	50	0,4261782
1	8,241855	9	0,194332	17	0,3465935
10	8,308794	10	0,202234	18	0,3760446
20	8,366777	20	0,209932	20	0,406446
30	8,417919	30	0,217609	30	0,4378142
40	8,463665	40	0,225092	40	0,4682128
50	8,505045	50	0,232444	50	0,4986075
2	8,542819	10	0,239670	18	0,5289982
10	8,577566	10	0,246795	10	0,5593851
20	8,609734	20	0,253761	20	0,5897682
30	8,639679	30	0,260633	30	0,6201476
40	8,667689	40	0,267395	40	0,6505234
50	8,693998	50	0,274049	50	0,6808955
3	8,718800	11	0,280599	19	0,7112642
10	8,742259	10	0,287048	10	0,7416294
20	8,764511	20	0,293399	20	0,7719911
30	8,785675	30	0,299655	30	0,8023495
40	8,805852	40	0,305815	40	0,8327046
50	8,825130	50	0,311899	50	0,8630565
4	8,843584	12	0,317879	20	0,8934052
10	8,861283	10	0,323780	10	0,9237507
20	8,878285	20	0,329599	20	0,9540931
30	8,894645	30	0,335337	30	0,9844325
40	8,910404	40	0,340996	40	1,0147689
50	8,925609	50	0,346579	50	1,0451024
5	8,940296	13	0,352088	21	0,9554329
10	8,954499	10	0,357524	10	0,9857606
20	8,968149	20	0,362889	20	1,0160855
30	8,981573	30	0,368185	30	1,0464075
40	8,994497	40	0,373414	40	1,0767269
50	9,007044	50	0,378577	50	1,1070435
6	9,019235	14	0,383675	22	0,9573575
10	9,031089	10	0,388711	10	0,9876689
20	9,042625	20	0,393685	20	1,0179777
30	9,053859	30	0,398600	30	1,0482840
40	9,064806	40	0,403455	40	1,0785877
50	9,075480	50	0,408254	50	1,1088890
7	9,085894	15	0,412956	23	0,9591878
10	9,096062	10	0,417684	10	0,9894842
20	9,105992	20	0,422317	20	1,0197783
30	9,115695	30	0,426899	30	1,0500700
40	9,125187	40	0,431429	40	1,0803594
50	9,134470	50	0,435918	50	1,1106465

The Table of Sines.

D.	M.	Sines	D.	M.	Sines	D.	M.	Sines
24	0	9,609313	32	0	9,724210	40	0	9,808067
	10	9,612148		10	9,726225		10	9,809569
	20	9,614944		20	9,728227		20	9,811061
	30	9,617727		30	9,730216		30	9,812544
	40	9,620488		40	9,732193		40	9,814019
	50	9,623229		50	9,734157		50	9,815485
25	0	9,625948	33	0	9,736109	41	0	9,816943
	10	9,628647		10	9,738048		10	9,818392
	20	9,631326		20	9,739975		20	9,819832
	30	9,633984		30	9,741889		30	9,821264
	40	9,636623		40	9,743792		40	9,822688
	50	9,639242		50	9,745683		50	9,824104
6	0	9,641842	34	0	9,747562	42	0	9,825511
	10	9,644423		10	9,749429		10	9,826910
	20	9,646984		20	9,751284		20	9,828301
	30	9,649527		30	9,753128		30	9,829683
	40	9,652052		40	9,754960		40	9,831058
	50	9,654558		50	9,756781		50	9,832425
27	0	9,657047	35	0	9,758591	43	0	9,833783
	10	9,659517		10	9,760390		10	9,835134
	20	9,661970		20	9,762177		20	9,836477
	30	9,664406		30	9,763954		30	9,837812
	40	9,666824		40	9,765720		40	9,839140
	50	9,669225		50	9,767474		50	9,840459
28	0	9,671609	36	0	9,769219	44	0	9,841771
	10	9,673977		10	9,770952		10	9,843079
	20	9,676328		20	9,772675		20	9,844372
	30	9,678663		30	9,774388		30	9,845662
	40	9,680982		40	9,776090		40	9,846944
	50	9,683284		50	9,777781		50	9,848218
29	0	9,685571	37	0	9,779463	45	0	9,849485
	10	9,687842		10	9,781134		10	9,850745
	20	9,690098		20	9,782796		20	9,851997
	30	9,692339		30	9,784447		30	9,853242
	40	9,694564		40	9,786088		40	9,854480
	50	9,696774		50	9,787720		50	9,855710
30	0	9,698970	38	0	9,789342	46	0	9,856934
	10	9,701151		10	9,790954		10	9,858150
	20	9,703317		20	9,792557		20	9,859360
	30	9,705469		30	9,794149		30	9,860562
	40	9,707606		40	9,795733		40	9,861757
	50	9,709730		50	9,797307		50	9,862946
31	0	9,711839	39	0	9,798872	47	0	9,864127
	10	9,713935		10	9,800427		10	9,865302
	20	9,716013		20	9,801971		20	9,866470
	30	9,718085		30	9,803510		30	9,867631
	40	9,720140		40	9,805038		40	9,868785
	50	9,722181		50	9,806557		50	9,869933

The Table of Sines.

D. M.	Sines	D. M.	Sines	D. M.	Sines
48	0 9,871073	56	0 9,918574	64	0 9,953660
10	9,872208	10	9,919424	10	9,954274
20	9,873335	20	9,920268	20	9,954883
30	9,874456	30	9,921107	30	9,955483
40	9,875571	40	9,921940	40	9,956083
50	9,876678	50	9,922768	50	9,956684
49	0 9,877780	57	0 9,923591	65	0 9,957276
10	9,878875	10	9,924409	10	9,957862
20	9,879961	20	9,925222	20	9,958445
30	9,881045	30	9,926029	30	9,959023
40	9,882121	40	9,926831	40	9,959596
50	9,883191	50	9,927628	50	9,960165
50	0 9,884254	58	0 9,928420	66	0 9,960730
10	9,885311	10	9,929207	10	9,961290
20	9,886361	20	9,929989	20	9,961846
30	9,887406	30	9,930766	30	9,962398
40	9,888444	40	9,931537	40	9,962945
50	9,889476	50	9,932304	50	9,963488
51	0 9,890503	59	0 9,933066	67	0 9,964026
10	9,891522	10	9,933822	10	9,964560
20	9,892536	20	9,934574	20	9,965090
30	9,893544	30	9,935320	30	9,965615
40	9,894546	40	9,936062	40	9,966136
50	9,895542	50	9,936799	50	9,966653
52	0 9,896532	60	0 9,937531	68	0 9,967166
10	9,897516	10	9,938257	10	9,967674
20	9,898494	20	9,938980	20	9,968178
30	9,899467	30	9,939697	30	9,968678
40	9,900433	40	9,940409	40	9,969173
50	9,901391	50	9,941116	50	9,969665
53	0 9,902349	61	0 9,941819	69	0 9,970152
10	9,903298	10	9,942517	10	9,970634
20	9,904241	20	9,943210	20	9,971112
30	9,905179	30	9,943898	30	9,971588
40	9,906111	40	9,944582	40	9,972058
50	9,907037	50	9,945261	50	9,972524
54	0 9,907958	62	0 9,945935	70	0 9,972986
10	9,908873	10	9,946604	10	9,973443
20	9,909782	20	9,947269	20	9,973897
30	9,910686	30	9,947929	30	9,974346
40	9,911584	40	9,948584	40	9,974792
50	9,912477	50	9,949235	50	9,975283
55	0 9,913364	63	0 9,949881	71	0 9,975760
10	9,914246	10	9,950522	10	9,976103
20	9,915123	20	9,951159	20	9,976532
30	9,915994	30	9,951791	30	9,976956
40	9,916859	40	9,952419	40	9,977377
50	9,917719	50	9,953042	50	9,977794

The Table of Sines.

D.	M.	Sines	D.	M.	Sines	D.	M.	Sines
72	0	9,978206	78	0	9,990404	84	0	9,997614
	10	9,978615		10	9,990671		10	9,997732
	20	9,979019		20	9,990934		20	9,997873
	30	9,979419		30	9,991193		30	9,997996
	40	9,979816		40	9,991447		40	9,998106
	50	9,980208		50	9,991699		50	9,998232
73	0	9,980596	79	0	9,991947	85	0	9,998344
	10	9,980980		10	9,992190		10	9,998453
	20	9,981361		20	9,992430		20	9,998558
	30	9,981737		30	9,992666		30	9,998659
	40	9,982109		40	9,992898		40	9,998757
	50	9,982477		50	9,993127		50	9,998851
74	0	9,982842	80	0	9,993351	86	0	9,998941
	10	9,983202		10	9,993572		10	9,999027
	20	9,983558		20	9,993789		20	9,999110
	30	9,983910		30	9,994003		30	9,999189
	40	9,984259		40	9,994212		40	9,999265
	50	9,984603		50	9,994418		50	9,999336
75	0	9,984943	81	0	9,994620	87	0	9,999404
	10	9,985280		10	9,994818		10	9,999469
	20	9,985613		20	9,995012		20	9,999529
	30	9,985942		30	9,995203		30	9,999586
	40	9,986266		40	9,995390		40	9,999640
	50	9,986587		50	9,995573		50	9,999689
76	0	9,986904	82	0	9,995753	88	0	9,999735
	10	9,987217		10	9,995918		10	9,999778
	20	9,987526		20	9,996100		20	9,999816
	30	9,987832		30	9,996269		30	9,999851
	40	9,988133		40	9,996433		40	9,999882
	50	9,988430		50	9,996594		50	9,999910
77	0	9,988724	83	0	9,996751	89	0	9,999934
	10	9,989014		10	9,996904		10	9,999954
	20	9,989299		20	9,997053		20	9,999971
	30	9,989581		30	9,997199		30	9,999983
	40	9,989860		40	9,997341		40	9,999993
	50	9,990134		50	9,997480		50	9,999998

CHAP. II.

*The Explanation and Use of the Table
of LOGARITHMS.*

He Table of Logarithms following consisteth of two Rows or Columns, the first of which (namely that towards the left hand, having the word *Num.* at the head thereof) containeth all absolute numbers increasing by a Unite in continual proportion from 1, to 1000.

In the other Column is placed the Logarithms of those absolute numbers; which Logarithms are numbers so fitted to proportional numbers, that themselves retain equal differences.

By this Table, the Logarithme of any absolute number under 1000, may be readily found: Or if any Logarithme, whose absolute number exceedeth not 1000, be given, this Table will plainly discover what absolute number answereth thereunto. The use of this Table will appear by the Propositions following.

PROP. I.

A number being given, to find the Logarithme thereof.

Let it be required to find the Logarithm of 223, First, seek 223 in the first Column of the Table under the word *Num.* and against it in the second Column you shall find 2,348305, which is the Logarithm thereof.

Also, Let it be required to find the Logarithm of 629, if you seek 629 in the first Column, against it in the second you shall find 2,798651, which is the Logarithm thereof.

PROP. II.

A Logarithme being given, how to find the absolute number thereunto belonging.

Let 2,731589 be a Logarithm given, whose absolute number you require: you must first seek this number in the second Column of the Table, under the word *Logar.* against which you shall find 539, which is the absolute number answering to that Logarithme.

But in this Table, as in the Table of *Sines*, if you cannot find the direct Logarithm which you look for in the Table, you must take the nearest thereunto.

THE

The Table of Logarithms.

<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>	<i>Num.</i>	<i>Logarith.</i>
1	0,000000	51	1,707570	101	2,004321
2	0,301030	52	1,716003	102	2,008600
3	0,477121	53	1,724276	103	2,012837
4	0,602060	54	1,732394	104	2,017033
5	0,698970	55	1,740363	105	2,021189
6	0,778151	56	1,748188	106	2,025306
7	0,845098	57	1,755875	107	2,029384
8	0,903090	58	1,763428	108	2,033424
9	0,954242	59	1,770853	109	2,037426
10	1,000000	60	1,778151	110	2,041393
11	1,041393	61	1,785330	111	2,045323
12	1,079181	62	1,792392	112	2,049218
13	1,115943	63	1,799341	113	2,053078
14	1,146128	64	1,806180	114	2,056905
15	1,176091	65	1,812913	115	2,060698
16	1,204120	66	1,819544	116	2,064458
17	1,230449	67	1,826075	117	2,068186
18	1,255272	68	1,832509	118	2,071883
19	1,278754	69	1,838849	119	2,075547
20	1,301030	70	1,845098	120	2,079181
21	1,322219	71	1,851258	121	2,082785
22	1,342423	72	1,857332	122	2,086359
23	1,361728	73	1,863323	123	2,089905
24	1,380211	74	1,869232	124	2,093422
25	1,397940	75	1,875061	125	2,096910
26	1,414973	76	1,880814	126	2,100371
27	1,431364	77	1,886491	127	2,103804
28	1,447158	78	1,892095	128	2,107209
29	1,462398	79	1,897627	129	2,110589
30	1,477121	80	1,903089	130	2,113943
31	1,491362	81	1,908485	131	2,117271
32	1,505150	82	1,913814	132	2,120574
33	1,518514	83	1,919078	133	2,123852
34	1,531479	84	1,924279	134	2,127105
35	1,544068	85	1,929419	135	2,130334
36	1,556302	86	1,934498	136	2,133539
37	1,568202	87	1,939519	137	2,136721
38	1,579783	88	1,944483	138	2,139879
39	1,591065	89	1,949390	139	2,143015
40	1,602060	90	1,954242	140	2,146128
41	1,612784	91	1,959041	141	2,149219
42	1,623249	92	1,963788	142	2,152288
43	1,633468	93	1,968483	143	2,155336
44	1,643453	94	1,973128	144	2,158362
45	1,653212	95	1,977724	145	2,161368
46	1,662758	96	1,982271	146	2,164353
47	1,672098	97	1,986772	147	2,167317
48	1,681241	98	1,991226	148	2,170262
49	1,690196	99	1,995635	149	2,173186
50	1,698970	100	2,000000	150	2,176091

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
151	2,178977	201	2,303196	251	2,399674
152	2,181844	202	2,305351	252	2,401401
153	2,184691	203	2,307496	253	2,403121
154	2,187521	204	2,309630	254	2,404834
155	2,190332	205	2,311754	255	2,406540
156	2,193125	206	2,313867	256	2,408239
157	2,195899	207	2,315970	257	2,409933
158	2,198657	208	2,318063	258	2,411619
159	2,201397	209	2,320146	259	2,413299
160	2,204119	210	2,322219	260	2,414973
161	2,206826	211	2,324282	261	2,416641
162	2,209515	212	2,326336	262	2,418301
163	2,212187	213	2,328379	263	2,419956
164	2,214844	214	2,330414	264	2,421604
165	2,217484	215	2,332438	265	2,423246
166	2,220108	216	2,334454	266	2,424882
167	2,222716	217	2,336459	267	2,426511
168	2,225309	218	2,338456	268	2,428135
169	2,227887	219	2,340444	269	2,429752
170	2,230449	220	2,342427	270	2,431364
171	2,232996	221	2,344392	271	2,432969
172	2,235528	222	2,346353	272	2,434569
173	2,238046	223	2,348305	273	2,436163
174	2,240548	224	2,350248	274	2,437751
175	2,243038	225	2,352183	275	2,439333
176	2,245513	226	2,354108	276	2,440909
177	2,247973	227	2,356026	277	2,442479
178	2,250420	228	2,357933	278	2,444045
179	2,252853	229	2,359835	279	2,445604
180	2,255273	230	2,361722	280	2,447158
181	2,257679	231	2,363612	281	2,448706
182	2,260071	232	2,365488	282	2,450249
183	2,262451	233	2,367356	283	2,451786
184	2,264818	234	2,369216	284	2,453318
185	2,267172	235	2,371068	285	2,454845
186	2,269513	236	2,372912	286	2,456365
187	2,271842	237	2,374748	287	2,457889
188	2,274158	238	2,376577	288	2,459392
189	2,276462	239	2,378398	289	2,460898
190	2,278754	240	2,380211	290	2,462393
191	2,281033	241	2,382017	291	2,463893
192	2,283301	242	2,383815	292	2,465383
193	2,285557	243	2,385606	293	2,466868
194	2,287802	244	2,387389	294	2,468347
195	2,290035	245	2,389166	295	2,469822
196	2,292256	246	2,390933	296	2,471292
197	2,294466	247	2,392697	297	2,472756
198	2,296665	248	2,394452	298	2,474216
199	2,298853	249	2,396199	299	2,475671
200	2,301029	250	2,397940	300	2,477121

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
301	2,473566	351	2,545507	401	2,603144
302	2,480007	352	2,546543	402	2,604226
303	2,481443	353	2,547775	403	2,605305
304	2,482874	354	2,549003	404	2,606381
305	2,484299	355	2,550228	405	2,607455
306	2,485721	356	2,551449	406	2,608526
307	2,487138	357	2,552668	407	2,609594
308	2,488551	358	2,553883	408	2,610660
309	2,489958	359	2,555094	409	2,611723
310	2,491362	360	2,556303	410	2,612784
311	2,492760	361	2,557507	411	2,613842
312	2,494155	362	2,558709	412	2,614897
313	2,495544	363	2,559907	413	2,615950
314	2,496929	364	2,561101	414	2,617000
315	2,498311	365	2,562293	415	2,618048
316	2,499687	366	2,563481	416	2,619093
317	2,501059	367	2,564666	417	2,620136
318	2,502427	368	2,565848	418	2,621176
319	2,503791	369	2,567026	419	2,622214
320	2,505149	370	2,568202	420	2,623249
321	2,506505	371	2,569374	421	2,624282
322	2,507856	372	2,570543	422	2,625312
323	2,509203	373	2,571709	423	2,626340
324	2,510545	374	2,572872	424	2,627366
325	2,511883	375	2,574031	425	2,628389
326	2,513218	376	2,575188	426	2,629409
327	2,514548	377	2,576341	427	2,630428
328	2,515874	378	2,577492	428	2,631444
329	2,517196	379	2,578639	429	2,632457
330	2,518514	380	2,579784	430	2,633468
331	2,519828	381	2,580925	431	2,634477
332	2,521138	382	2,582063	432	2,635484
333	2,522444	383	2,583199	433	2,636488
334	2,523746	384	2,584331	434	2,637489
335	2,525045	385	2,585461	435	2,638489
336	2,526339	386	2,586587	436	2,639486
337	2,527629	387	2,587711	437	2,640481
338	2,528916	388	2,588832	438	2,641475
339	2,530199	389	2,589949	439	2,642465
340	2,531479	390	2,591065	440	2,643453
341	2,532754	391	2,592177	441	2,644439
342	2,534026	392	2,593286	442	2,645422
343	2,535294	393	2,594393	443	2,646404
344	2,536558	394	2,595496	444	2,647383
345	2,537819	395	2,596597	445	2,648360
346	2,539076	396	2,597695	446	2,649335
347	2,540329	397	2,598790	447	2,650308
348	2,541579	398	2,599883	448	2,651278
349	2,542825	399	2,600973	449	2,652246
350	2,544068	400	2,602059	450	2,653213

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
451	2,654177	501	2,699338	551	2,741152
452	2,655138	502	2,700704	552	2,741939
453	2,656098	503	2,701568	553	2,742725
454	2,657056	504	2,702430	554	2,743509
455	2,658011	505	2,703291	555	2,744293
456	2,658965	506	2,704151	556	2,745075
457	2,659916	507	2,705008	557	2,745855
458	2,660865	508	2,705864	558	2,746634
459	2,661813	509	2,706718	559	2,747412
460	2,662758	510	2,707570	560	2,748188
461	2,663701	511	2,708421	561	2,748963
462	2,664642	512	2,709269	562	2,749736
463	2,665581	513	2,710117	563	2,750508
464	2,666518	514	2,710963	564	2,751279
465	2,667453	515	2,711807	565	2,752048
466	2,668386	516	2,712649	566	2,752816
467	2,669317	517	2,713491	567	2,753583
468	2,670246	518	2,714329	568	2,754348
469	2,671173	519	2,715167	569	2,755112
470	2,672098	520	2,716003	570	2,755875
471	2,673021	521	2,716838	571	2,756636
472	2,673942	522	2,717671	572	2,757396
473	2,674861	523	2,718502	573	2,758155
474	2,675778	524	2,719331	574	2,758912
475	2,676694	525	2,720159	575	2,759668
476	2,677607	526	2,720986	576	2,760422
477	2,678518	527	2,721811	577	2,761176
478	2,679428	528	2,722634	578	2,761928
479	2,680336	529	2,723456	579	2,762679
480	2,681241	530	2,724276	580	2,763428
481	2,682145	531	2,725095	581	2,764176
482	2,683047	532	2,725912	582	2,764923
483	2,683947	533	2,726727	583	2,765669
484	2,684845	534	2,727541	584	2,766413
485	2,685742	535	2,728354	585	2,767156
486	2,686636	536	2,729165	586	2,767898
487	2,687529	537	2,729974	587	2,768638
488	2,688419	538	2,730782	588	2,769377
489	2,689309	539	2,731589	589	2,770115
490	2,690196	540	2,732394	590	2,770852
491	2,691081	541	2,733197	591	2,771587
492	2,691965	542	2,733999	592	2,772322
493	2,692847	543	2,734799	593	2,773055
494	2,693727	544	2,735599	594	2,773786
495	2,694605	545	2,736397	595	2,774517
496	2,695482	546	2,737192	596	2,775246
497	2,696356	547	2,737987	597	2,775974
498	2,697229	548	2,738781	598	2,776701
499	2,698101	549	2,739572	599	2,777427
500	2,698970	550	2,740363	600	2,778151

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
601	2,778874	651	2,813581	701	2,845718
602	2,779596	652	2,814248	702	2,846337
603	2,780317	653	2,814913	703	2,846955
604	2,781037	654	2,815578	704	2,847573
605	2,781755	655	2,816241	705	2,848189
606	2,782473	656	2,816904	706	2,848805
607	2,783189	657	2,817565	707	2,849419
608	2,783904	658	2,818226	708	2,850033
609	2,784617	659	2,818885	709	2,850646
610	2,785329	660	2,819543	710	2,851258
611	2,786041	661	2,820201	711	2,851869
612	2,786751	662	2,820858	712	2,852479
613	2,787460	663	2,821514	713	2,853089
614	2,788164	664	2,822168	714	2,853698
615	2,788875	665	2,822822	715	2,854306
616	2,789581	666	2,823474	716	2,854913
617	2,790285	667	2,824126	717	2,855519
618	2,790988	668	2,824776	718	2,856124
619	2,791691	669	2,825426	719	2,856729
620	2,792392	670	2,826075	720	2,857332
621	2,793092	671	2,826723	721	2,857935
622	2,793791	672	2,827369	722	2,858537
623	2,794488	673	2,828015	723	2,859138
624	2,795185	674	2,828659	724	2,859739
625	2,795880	675	2,829304	725	2,860338
626	2,796574	676	2,829947	726	2,860937
627	2,797268	677	2,830589	727	2,861534
628	2,797959	678	2,831229	728	2,862131
629	2,798651	679	2,831869	729	2,862728
630	2,799341	680	2,832509	730	2,863323
631	2,800029	681	2,833147	731	2,863917
632	2,800717	682	2,833784	732	2,864511
633	2,801404	683	2,834421	733	2,865104
634	2,802080	684	2,835056	734	2,865696
635	2,802774	685	2,835691	735	2,866287
636	2,803457	686	2,836324	736	2,866878
637	2,804139	687	2,836957	737	2,867467
638	2,804821	688	2,837588	738	2,868056
639	2,805501	689	2,838219	739	2,868643
640	2,806179	690	2,838849	740	2,869223
641	2,806858	691	2,839478	741	2,869818
642	2,807535	692	2,840106	742	2,870404
643	2,808211	693	2,840733	743	2,870989
644	2,808886	694	2,841359	744	2,871573
645	2,809559	695	2,841985	745	2,872156
646	2,810233	696	2,842609	746	2,872739
647	2,810904	697	2,843233	747	2,873321
648	2,811575	698	2,843855	748	2,873902
649	2,812245	699	2,844477	749	2,874482
650	2,812913	700	2,845098	750	2,875061

The Table of Logarithms.

Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
751	2,875639	801	2,901613	851	2,929929
752	2,876218	802	2,902174	852	2,930519
753	2,876795	803	2,902716	853	2,931049
754	2,877371	804	2,903256	854	2,931458
755	2,877947	805	2,903796	855	2,931966
756	2,878522	806	2,904335	856	2,932474
757	2,879095	807	2,904874	857	2,932981
758	2,879669	808	2,905411	858	2,933487
759	2,880242	809	2,905949	859	2,933993
760	2,880814	810	2,906485	860	2,934498
761	2,881385	811	2,907021	861	2,935003
762	2,881955	812	2,907556	862	2,935507
763	2,882525	813	2,908091	863	2,936011
764	2,883093	814	2,908624	864	2,936514
765	2,883661	815	2,909156	865	2,937016
766	2,884229	816	2,909690	866	2,937518
767	2,884795	817	2,910222	867	2,938019
768	2,885361	818	2,910773	868	2,938519
769	2,885926	819	2,911324	869	2,939019
770	2,886491	820	2,911814	870	2,939519
771	2,887054	821	2,912345	871	2,940018
772	2,887617	822	2,912872	872	2,940516
773	2,888179	823	2,913399	873	2,941014
774	2,888741	824	2,913927	874	2,941511
775	2,889302	825	2,914454	875	2,942008
776	2,889862	826	2,914980	876	2,942504
777	2,890421	827	2,915506	877	2,942999
778	2,890979	828	2,916030	878	2,943495
779	2,891537	829	2,916555	879	2,943989
780	2,892095	830	2,917078	880	2,944483
781	2,892651	831	2,917601	881	2,944976
782	2,893207	832	2,918123	882	2,945468
783	2,893762	833	2,918645	883	2,945961
784	2,894316	834	2,919166	884	2,946452
785	2,894869	835	2,919685	885	2,946943
786	2,895423	836	2,920206	886	2,947434
787	2,895975	837	2,920725	887	2,947924
788	2,896526	838	2,921244	888	2,948415
789	2,897077	839	2,921762	889	2,948902
790	2,897627	840	2,922279	890	2,949390
791	2,898176	841	2,922796	891	2,949878
792	2,898725	842	2,923312	892	2,950365
793	2,899273	843	2,923825	893	2,950851
794	2,899821	844	2,924334	894	2,951338
795	2,900367	845	2,924857	895	2,951823
796	2,900913	846	2,925370	896	2,952308
797	2,901458	847	2,925883	897	2,952792
798	2,902003	848	2,926396	898	2,953276
799	2,902547	849	2,926908	899	2,953759
800	2,903089	850	2,927419	900	2,954243

The Table of Logarithms.

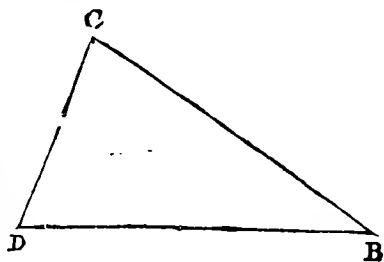
Num.	Logarith.	Num.	Logarith.	Num.	Logarith.
901	2,954725	935	2,970812	968	2,985875
902	2,955207	936	2,971276	969	2,986324
903	2,955688	937	2,971739	970	2,986772
904	2,956168	938	2,972203	971	2,987219
905	2,956640	939	2,972666	972	2,987666
906	2,957128	940	2,973128	973	2,988113
907	2,957607	941	2,973589	974	2,988559
908	2,958086	942	2,974050	975	2,989005
909	2,958564	943	2,974512	976	2,989449
910	2,959041	944	2,974972	977	2,989895
911	2,959518	945	2,975432	978	2,990339
912	2,959995	946	2,975891	979	2,990783
913	2,960471	947	2,976349	980	2,991226
914	2,960946	948	2,976808	981	2,991669
915	2,961421	949	2,977266	982	2,992111
916	2,961895	950	2,977724	983	2,992554
917	2,962369	951	2,978181	984	2,992995
918	2,962842	952	2,978637	985	2,993436
919	2,963315	953	2,979093	986	2,993877
920	2,963788	954	2,979548	987	2,994317
921	2,964259	955	2,980003	988	2,994756
922	2,964731	956	2,980458	989	2,995196
923	2,965202	957	2,980912	990	2,995635
924	2,965672	958	2,981366	991	2,996074
925	2,966142	959	2,981819	992	2,996512
926	2,966611	960	2,982271	993	2,996949
927	2,967079	961	2,982723	994	2,997386
928	2,967548	962	2,983175	995	2,997823
929	2,968016	963	2,983626	996	2,998259
930	2,968483	964	2,984077	997	2,998695
931	2,968949	965	2,984527	998	2,999133
932	2,969416	966	2,984977	999	2,999565
933	2,969882	967	2,985426	1000	3,000000
934	2,970347				

CHAP. III.

The use of the Tables of Sines and Logarithms in the resolving of Plain Triangles.

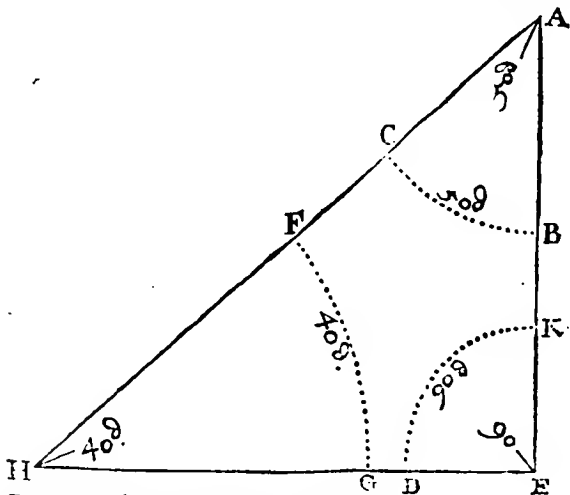
BEfore I come to shew how the quantity of the sides and angles of any Triangle may be found by help of the former Tables, it will be convenient first to deliver these following considerations and Theoremes, as necessities thereunto.

1 A Triangle is a figure consisting of three sides and three angles, as is the figure DBC.



2 Any two sides of a Triangle are called the sides of the angle comprehended by them, as the sides CB and DB are the sides containing the angle CBD.

3 The measure of an Angle, is the quantity of an arch of a Circle described on the angular point, and cutting both the containing sides of the same angle, as in the Triangle following, the arch CB, is the measure of the angle at A; the arch KD is the measure of the angle at E; and the arch FG is the measure of the angle at H; each of these arches are described on the angular points A, H, E, and cut the containing sides.



4 A Degree is the 360 part of any Circle.

5 A Semicircle containeth 180 degrees.

6 A Quadrant containeth 90 degrees.

7 The complement of an angle lesse then a Quadrant, is so much as that angle wanteth of 90 degrees, as if the angle HAE should contain 50 degrees, the complement thereof would be 40 degrees, for if you take 50 from 90 there will remain 40.

8 The

8 The complement of an angle to a Semicircle, is the remainder thereof to 180 degrees.

9 An angle is either Right, Acute, or Obtuse.

10 A Right angle is that whose measure is a Quadrant.

11 An Acute angle is less than a right angle.

12 An Obtuse angle is greater than a Quadrant.

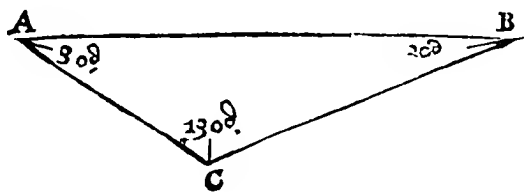
13 A Triangle is either Right angled, or Oblique angled.

14 A Right angled Triangle is that which hath one right angle, as the Triangle A H E is right angled at E.

15 In every right angled Triangle, that side which subtendeth or lieth opposite to the right angle, is called the Hypotenusal, and of the other two sides, the one is called the Perpendicular, and the other the Base, at pleasure, but most commonly the shortest is called the Perpendicular, and the longer is called the Base. So in the former Triangle, the side A H is the Hypotenusal, H E the Base, and A E the Perpendicular.

16 In every right angled Triangle, if you have one of the acute angles given, the other is also given, it being the complement thereof to 90 degrees. As in the Triangle A H E, suppose there were given the angle A H E 40 degrees, then by consequence the angle H A E must be 50 degrees, which is the complement of the other to 90 degrees.

17 The three angles of any right lined Triangle whatsoever, are equal to two right angles, or to 180 degrees; so that if in any right lined Triangle, you have any two of the angles given, you have the third angle also given, it being the complement of the other two to 180 degrees.



So in this Triangle A B C, if there were given the angle B A C 30 degrees, and the angle A C B 130 degrees, I say by consequence there is also given the third angle A B C 20 degrees, it being the complement of the other two to 180 degrees: for, the two given angles 30 and 130 being added together, they make 160, which being taken from 180, there remains 20, the quantity of the third angle A B C.

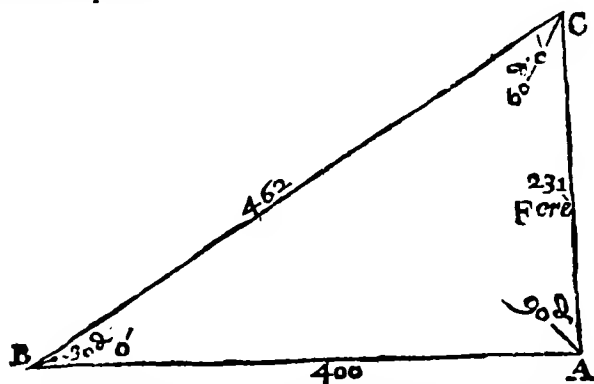
18 In all plain Triangles whatsoever, the sides are in proportion one to the other, as the Sines of the angles opposite to those sides. So in the Triangle A B C, the Sine of the angle A C B, is in such proportion to the side A B, as the Sine of the angle C A B is to the side B C, and so of any other.

CHAP. IV.

Containing the doctrine of the dimension of right lined Triangles, whether right angled or oblique angled, and the severall Cases therein resolved, both by tables, and also by the Lines of Artificiall Numbers, Sines, and Tangents.

HAVING in the foregoing Chapters of this Book explained and shewed the use of the Tables of Sines and Logarithms, and also delivered divers necessary Theorems relating to the mensuration of plain Triangles, I come now to shew how a plain Triangle may be resolved, that is, by having any three of the six parts of a plain Triangle given, to finde a fourth, both by the Tables of Sines and Logarithms, and also by the lines of Artificiall Numbers, Sines and Tangents on the Index of your Table, so that when your Tables are not ready at hand, you may make use of these Lines which will sufficiently supply the want of them.

In all the cases following, I have made use but of two Triangles for Examples, one right angled, and the other oblique angled, but in either of them I have expressed all the varieties that are necessary, so that any three parts being given in any of them, a fourth may be found at pleasure.



The severall cases of the right angled triangle will best be applied in the taking of heights, as is shewed in the next Book, and the oblique angled Triangle for the taking of distances there also taught; so that if the line CA in the right angled Triangle were a Tree, Tower, or Steeple and that you would know the height thereof, you must observe with your Instrument the Angle CBA, and measure the distance BA; so have you in the right angled Triangle ABC the Base AB, and the angle at the Base CBA, then may you (by the 1. Case) finde the side CA, which is the height of the thing required.

In the resolving of plain Triangles, there are severall Cases, of which; I will only insist on those that have most relation to the work in hand. And first,

Of Right angled plain Triangles.

CASE I.

In a right angled plain Triangle, the Base and the angle at the Base being given, to finde the Perpendicular.

IN the right angled Triangle following A B C, there is given, the Base thereof B A, 400 foot and the angle at the Base C B A 30 degrees, and it is required to finde the perpendicular C A.

Now because the angle C B A is given, the angle B C A is also given; it being the complement of the other to 90 degrees; and therefore the angle B C A is 60 degrees. Then to finde the perpendicular C A, the proportion is,

As the sine of the angle B C A, 60 degrees (which is) 9,937531

Is to the Logarithm of the side B A, 400 foot (which is) 2,602059

So is the sine of the angle C B A 30 degrees (which is) 9,698970

the sum of the second and third numbers added--12,301029

the first number subtracted from the sum--9,937531

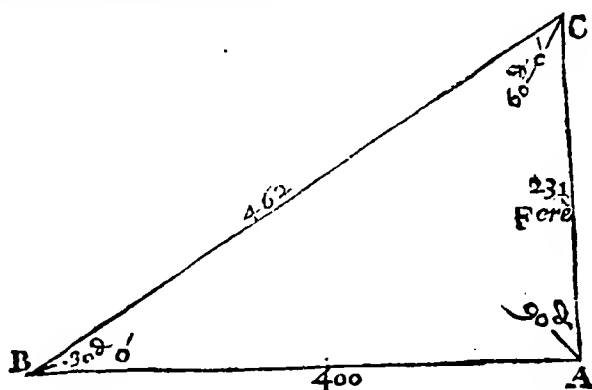
To the Logarithm of the side C A (which is) 2,363498

The neereſt absolute number answering to this Logarithm is 231 feet, and that is the length of the side C A in feet, which was the thing required.

A generall Rule.

In all proportions wrought by sines and Logarithms, you must observe this for a generall rule, viz. to adde the second and third numbers together, and from the sum of them to subtract the first number, so shall the remainder answer your question demanded, as by the former work you may perceive, where the Logarithm of the side B A 2,602059 (which is the second term) is added to the sine of the angle C B A 9,698970, (which is the third term) and from the sum of them (namely from 12,301029 is subtracted 9,937531, the sine of the angle B C A, which is the first number, and there remaineth, 2,363498, which is the Logarithme of 231 almost, and that is the length of the side required in feet.

The same manner of worke is to be observed in all the Cases following as will plainly appear.



How to perform the same work, by the lines of Sines and Numbers.

These kinde of proportions are wrought more easily by help of the lines of artificiall Numbers, Sines and Tangents on the Index of your Table, and exact enough for any ordinary occasion, for the proportion being,

As the sine of the angle B C A, 60 degrees,
Is to the Logarithm of the side B A 400 feet;
So is the sine of the angle C B A, 30 degrees;
To the Logarithm of the side A C 231 feet, *scilicet*.

Therefore, if you set one foot of your Compasses at 60 degrees in the line of Sines and extend the other foot to 400 in the line of Numbers; the same extent of the Compasses will reach from the Sine of 30 degrees to 231 in the line of Numbers, which is the length of the side A C, which was required

Or otherwise, Extend the Compasses from the sine of 30 degrees to the sine of 60 degrees, in the line of Sines, the same extent will also reach from 400, in the line of Numbers, to 231 as before. And thus by these Artificiall Lines, the work is much abbreviated there being need neither of pen, inke, paper, or Tables, but only of your Compasses.

CASE II.

*The Base, and the angle at the Base being given,
to finde the Hypothenusall.*

IN the same Triangle ABC let there be given (as before) the Base AB 400 foot, and the angle ABC 30 degrees, and let it be required to finde the Hypothenusall BC . Now because the angle CBA is given, the other angle BCA is also given, and the proportion is,

As the sine of the angle BCA , 60 degrees,	9.937531
Is to the Logarithm of the side BA 400 feet,	2.602059
So is the sine of the angle CAB 90 degrees:	10.000000

the sum of the second and third numbers added--	12.602959
the first number subtracted from the sum--	9.937531

To the Logarithm of the side BC : which is,	2.665428
---	----------

The absolute number answering to this Logarithm is 462, and so many feet is the Hypothenusall BC .

By the Lines of Sines and Numbers:

The manner of work is altogether the same with the former, for the proportion being.

As the Sine of the angle BCA 60 degrees,
Is to the length of the side BA 400 foot;
So is the sine of the angle CAB 90 degrees,
To the length of the side CB 462.

Extend the Compasses from the sine of 60 degrees to 400 in the line of Numbers, the same extent will reach from the Sine of 90 degrees to 462 in the line of Numbers, and that is length of the side BC .

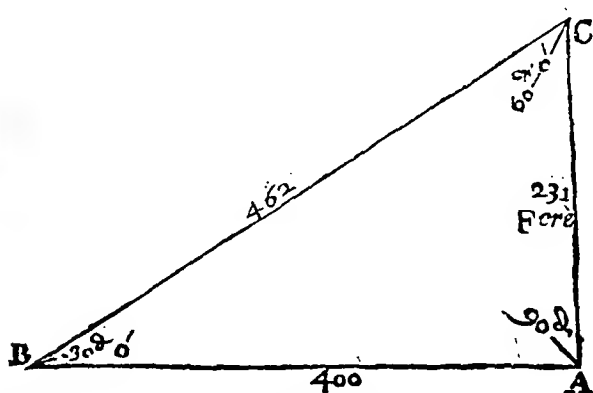
Or you may extend the Compasses from the Sine of 60 degrees to the Sine of 90 degrees, the same extent will also reach from 400 to 462, as before.

CASE III.

*The Hypothenusall, and angle at the Base being
given, to finde the Perpendicular.*

IN the same Triangle, let there be given the Hypothenusall BC 462 feet, and the angle at the Base CBA 30 degrees, to find the perpendicular CA .

The angle C A B is a right angle or 90 degrees, therefore the proportion is,



As the Sine of the angle C A B 90 degrees,
Is to the Logarithme of the side B C 462;
So is the Sine of the angle C B A 30 degrees,

10,0 00000
2,664642
9,698970

To the Logarithme of the side C A

12,363612

The number answering to this Logarithme is 231 *ferè*, and that is the length of the side C A in feet.

Here the Work is somewhat abbreviated, for the angle C A B being a right angle, and being the first term, when the second and third terms are added together, the first is easily subtracted from it by cancelling the figure next your left hand; as you see in the example; and so the rest of that number is the Logarithme of the number sought.

By the lines of Sines and Numbers.

Extend the Compasses from the Sine of 90 degrees to 462, the same extent will reach from the Sine of 30 degrees to 231.

Or extend the Compasses from the Sine of 90 degrees to the Sine of 30 degrees, the same extent will reach from 462 to 231; and that is the side C A.

CASE IV.

The Hypothensal and angle at the Base being given, to finde the Base.

L Et there be given in the former Triangle the Hypothensal B C, and the angle at the base C B A, and by consequence the angle B C A the complement of the other to 90; then to finde B A, the proportion is,

As

As the Sine of the angle C A B, 90 degrees	10,000000
Is to the Hypothenuſall B C, 462	2,664642
So is the Sine of the angle B C A, 60 degrees,	9,937531

To the Logarithm of the Baſe B A,	12,602173
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The neceſſt number anſwering to 2,602173, is the Logarithm of 400, and ſo long is the Baſe B A.

By the lines of Sines and Numbers.

As before, Extend the Compaſſes from the Sine of 90, to 462, the ſame extent will reach from the ſine of 60 degrees, to 400 in the line of Numbers.

Or, extend the Compaſſes from the ſine of 90, to the Sine of 60, the ſame extent will reach from 462 to 400, which is the length of the Baſe B A.

CASE V.

The Perpendicular, and angle at the Baſe being given, to finde the Hypothenuſall.

IF the Perpendicular C A be given 231, and the angle at the Baſe C B A 30 degrees, the Hypothenuſall B C may be found thus; for,

As the ſine of the angle C B A, 30 degrees,	9,698970
---	----------

Is to the Logarithm of the perpendicular C A 231	12,363612
--	-----------

So is the Sine of the angle C A B, 90 degrees,	10,000000
--	-----------

To the Logarithm of the Hypothenuſall B C	2,664642
---	----------

¶ Here, becauſe the angle C A B is a right angle, or 90 degrees, and comes in the third place, I therefore only put an unite before the ſecond term, and from that ſecond term ſubſtract the firſt terme, and the remainder is, 2,664642, the abſolute number anſwering thereunto is 462, the ſide B C.

By the lines of Sines and Numbers.

Extend the Compaſſes from the ſine of 30 degrees, to 231, the ſame extent will reach from the ſine of 90 degrees to 462.

Or, the diſtance between the Sine of 30 degrees and 90 degrees, will be equall to the diſtance between 231, and 462, which giveth the ſide required.

CASE

CASE VI.

The Hypothenufall and Perpendicular being given to finde the angle at the Base.

IN the foregoing Triangle there is given the Hypothenufall B C 462 feet, and the perpendicular C A, 231 feet, and it is required to finde the angle C B A, the proportion is,

As the Logarithm of the Hypothenufall B C 462	2,664642
Is to the right angle B A C, 90 degrees,	10,000000
So is the Logarithm of the perpendicular C A, 231,	12,363612
To the sine of the angle C B A, 30 degrees.	9,698970

By the Lines of Sines and Numbers:

Extend the Compasses from 462, to the sine of 90, the same extent will reach from 231 to the sine of 30 degrees.

Or, Extend the Compasses from 62 to 23, the same extent will reach from the sine of 90 degrees, to the sine of 30 degrees, which is the quantity of the enquired angle C B A.

Of oblique angled plain Triangles.

CASE VII.

Having two angles and a side opposite to one of them given, to finde the side opposite to the other.

IN the Triangle Q R S, there is given the angle Q S R 24 deg. 20 min. and the angle Q R S 45 degrees 10 minutes, and the side Q S 303 feet, and it is required to finde the side Q R.

¶ Here note, that in oblique angled plain Triangles, as well as in Right angled, the sides are in proportion one to the other, as the Sines of the angles opposite to those sides. Therefore,

As the sine of the angle Q R S 45 deg. 10 min.	9,850745
Is to the Logarithm of the side Q S 303 feet,	2,481443
So is the sine of the angle Q S R 24 degrees 20 min.	9,614944

the sum of the second and third terms--12,096387
the first terme subtracted--9,850745

To the Logarithm of the side Q R,	2,245642
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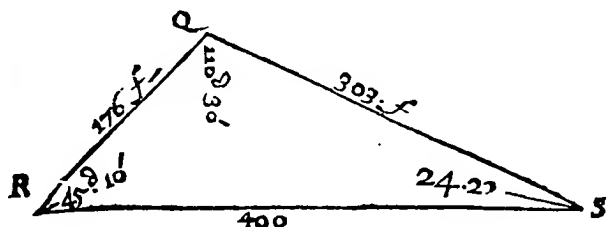
The neereft absolute number answering to this Logarithm is 176, and so many feet is the side Q R.

By the lines of Sines and Numbers.

The lines of Sines and Numbers will resolve these Triangles by the same manner of work as in the other before. For,

If you extend the Compasses from the Sine of 45 deg. 10 min. to 303, the same extent will reach from the Sine of 24 degrees 20 minutes, to 176, and so much is the side QR.

Or, Extend the Compasses from the Sine of 45 degrees 10 min. to 24 degrees 20 minutes, the same Extent will reach from 303, to 176, the length of the inquired side.



In like manner, if the Angle RQS 110 degrees 30 minutes, and the Angle QRS 45 degrees 10 minutes, and the side QS 303 feet, had been given, and the side RS required, the manner of work had been the same; for,

As the sine of the Angle QRS 45 degrees 10 min. 9,850745

Is to the Logarithm of the side QS 303 feet, 2,481443

So is the Sine of RQS 110 deg. 30 min. (or 69 deg. 30 m.) 9,971588

the sum of the second and third terms-- 12,453031
the first terme subtracted-- 9,850745

To the Logarithm of the side RS, 2,602286

The absolute number answering to this Logarithm is 400, and so much is the side RS.

☛ In this case, because the angle RQS is more then 90 degrees, you must therefore take the complement thereof to 180 degrees, so 110 degrees 30 minutes, being taken from 180 degrees, there remains 69 degrees 30 min. whose Sine is the same with 110 deg. 30 min. and being used in stead thereof, will effect the same thing.

By the lines of Sines and Numbers.

Extend the Compasses from the Sine of 45 degrees 10 min. to 303, the same extent will reach from the sine of 69 deg. 30 min. to 400, which is the side RS required.

Or

Or the Compasses being opened to the distance between the sine of 45 deg. 10 min. and 69 deg. 30 min. the same distance will reach from 303 to 400 as before.

CASE VIII.

Two sides and an angle opposite to one of them being given, to find the angle opposite to the other.

IN the same Triangle, let there be given, the side QS 303, and IQR 176, together with the angle QSR 24 degrees 20 minutes, and let it be required to find the angle QRS, the proportion is,

As the Logarithm of the side QR 176, 2,245513

Is to the sine of the angle QSR, 24 deg. 20 min. 9,614944

So is the Logarithm of the side QS 303. 2,481443

The sum of the second and third numbers 12,096387

The first number subtracted from the sum 2,245513

To the sine of the angle QRS. 9,850374

The nearest degree answering to this sine is 45 degrees 10 min. which is the quantity of the angle QRS, required.

By the lines of Sines and Numbers.

Extend the Compasses from 176, to the sine of 24 degrees 20 minutes, the same extent will reach from 303 to 45 deg. 10 min. the angle QRS.

Or, the distance between 176 and 303, will be equal to the distance between 24 degrees 20 minutes, and 45 deg. 10 min.

CASE IX.

Having two sides, and the angle contained by them given, to find either of the other angles.

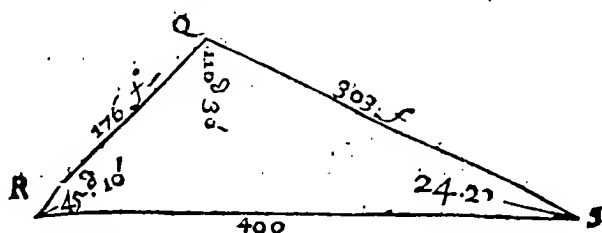
THIS Case will seldom come in use in Surveying, because the thing required is an angle, which are most commonly given, they being observed by Instrument, and therefore in this place may be omitted, partly because the proposition is not wrought by Sines and Logarithms, but by Tangents and Logarithms; and there is no Tables of Tangents in this Book, to work the proportion by: Yet those that are desirous to resolve all kinde of Triangles by the proportionall lines, may have added to the lines of artificial sines and Numbers, a line of artificial Tangents, and these three lines

together, will resolve all Cases in Spherical, as well as in plain Triangles.

For the performance of this Probleme, suppose there were given the side QS 303, and the side RQ 176, and the angle comprehended by them; namely, the angle RQS 110 degrees 30 minutes, and it were required to find either of the other angles.

First, Take the sum and difference of the two given sides, their sum is 479, and their difference is 127. Then knowing that the three angles of all right lined Triangles are equal to two right angles, or 180 deg. (by the 17 Theor. of Chap. 3.) therefore the angle RQS being 110 deg. 30 minutes, if you subtract this angle from 180 degrees, the remainder will be 69 deg. 30 min. which is the sum of the two unknown angles at R and S, the half whereof is 34 deg. 45 min.

The side QS,	303
The side RQ	176
<hr/>	
The sum of the sides,	479
The difference of the sides,	127
The half sum of the two unknown angles 34 deg. 45 min.	



The sum and difference of the sides being thus found, and also the half sum of the two unknown angles, the proportion by which you must find the angles severally is,

As the Logarithm of the sum of the sides, 479,	2,680335
Is to the Logarithm of the difference of the sides, 127,	2,103804
So is the Tangent of the half sum of the two unknown angles 34 degrees, 45 minutes,	9,841187
<hr/>	
the sum of the second and third numbers	11,944991
the first number subtracted	2,680335
<hr/>	
To the Tangent of 10 degrees 25 minutes,	9,364656

These

These ten degrees 25 minutes, being added to the half sum of the two unknown angles, namely, to 34 degrees 45 minutes; the sum will be 45 degrees 10 minutes, the quantity of the angle QRS, which is the greater angle of the two: Also, these ten degrees 25 minutes, being subtracted from the same half sum, there remaineth 24 degrees 20 minutes for the angle QSR, which is the lesser of the unknown angles; and thus are either of the enquired angles easily found.

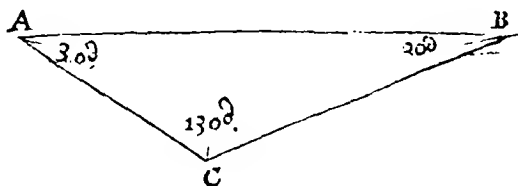
By the lines of Tangents and Numbers.

Extend the Compasses from the sum of the sides 479, to the difference of the sides 127, the same extent upon the line of Tangents will reach from the Tangent of 34 degrees 45 minutes (which is the half sum of the two unknown angles) to the Tangent of ten degrees 25 minutes, and these ten degrees 25 minutes, added to, and subtracted from the half sum, as before is shewed, will give the quantity of either of the two unknown angles.

CASE X.

The three sides of a right lined Plain Triangle being given, how to finde the Area, or the superficial content thereof.

First, Add the three sides together, and from the half summe subtract each side severally, to the end you may have the difference betwixt that halfe summe and each side: this done adde



the Logarithms of the said halfe summe, and of those differences together: and lastly, dividing the summe of those Logarithms by 2, you have the Logarithm of the superficial content or area of the Triangle.

EXAMPLE.

Let the Triangle given be ABC, the sides thereof being 20, 13, 11, how much is the superficial content thereof?

The sum of the sides is 44, the half summe is 22, the differences betwixt each side and that half are 2, 9, 11, which numbers rank in this order following.

The half sum,	22	1,342423
	$\left. \begin{array}{l} 2 \\ 9 \\ 11 \end{array} \right\}$	0,301030
The differences,		0,954243
		1,041393
The sum of the Logarithms		3,639089
The Area or Content required, 66.		1,819544

And this Area, or superficial Content thus found, is alwayes of the same nature with the sides of the Triangle, that is to say, if the sides of the Triangle, be given in feet, then is the content found in feet, also, if the sides be Perches, you shall have the content in Perches, and so of any other measure whatsoever. I might add hereunto divers other Cases, but in this place at present let these suffice.

The end of the third Book.



THE COMPLEAT SURVEYOR:

The Fourth Book.

THE ARGUMENT.

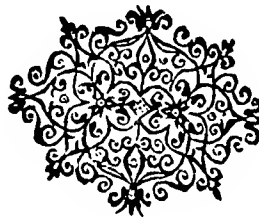


L hath hitherto been our business to provide necessary Instruments, and to learn such things, which of necessity ought to be known before we enter the Fields to Survey. Being thus provided, we come now to apply them several ways: First, in taking of Heights and Distances whether accessible or in-accessible; and then in Surveying of Land. In this Book every kinde of work is performed three several ways, by three several Instruments, viz. the *Plain Table*, the *Theodolite*, and *Circumferentor*, by which the congruity and harmony of the several Instruments may be

A a

easily

easily discerned, and the truth of every *Example* may the better appear. Here is also divers ways of *Surveying* by one and the same *Instrument*, that is, to take the *Plot* of a *Field* several ways, and to measure all kind of *Grounds* whatsoever, whether *Woodland* or other. Here is also shewn how to take the *Plot* of a whole *Mannor*, and to keep your *account* in your *Field Book*, after the best and most easiest manner: with divers *Rules*, *Cautions* and *Directions*, throughout the whole *Book* inserted.





THE APPLICATION AND VSE of the severall Instruments (before described) in the practice of SURVEYING.

CHAP. I.

The use of the Scale.



Having before described the severall Instruments belonging to Surveying, I will now shew the use of them: and first, of the Scale. The Scale is principally intended for the laying out of lines, for which purpose the severall Scales of equal parts are there divided, some of greater and some of lesser quantities: the uses of all the lines being the same, for each line is divided into certain equal parts representing 11 Chains, & these grand divisions are numbred with Arithmetickall Figures by 1, 2, 3, &c. to 10, then the uppermost large division is again divided into ten other smaller parts, each part containing 10 links of your chain, each of which smaller parts you may suppose to be again divided into ten other lesser parts, representing single Links of your Chain.

1 *Any length being measured by your Chain, how to lay down the same distance upon Paper.*

Suppose, that measuring a long a hedge with your Chain, you finde the length thereof to contain 5 Chains 60 Links: Now to take this distance from your Scale, and lay it down upon paper do thus. First, Draw a line as AB, then place one foot of your Compasses upon your Scale at the figure 5. for your five Chains, and

B

C

D

E

A

extend the other foot to six of the small divisions (which represents the 60 Links) then set this distance upon the line drawn from A to B, so shall the line A B contain 5 Chains 60 Links, if you take the distance from the Scale of 10 in an Inch.

But if you would have your line shorter, and yet to contain 5 Chains 60 links, then take your distance from a smaller Scale, as of 12, 16, 20, or 24 in an Inch, so shall the 5 Chains 60 Links end at C, if taken from the Scale of 12 in an inch, or at D, by the Scale of 16, or at E by the Scale of 24: either of which lines will contain 5 Chains 60 Links, and be in proportion one to the other as the Scales from whence they were taken. And in this manner may any number of Chains and Links be taken from any of the Scales.

2 A right line being given, to find how many Chains and Links are therein contained, according to any Scale assigned.

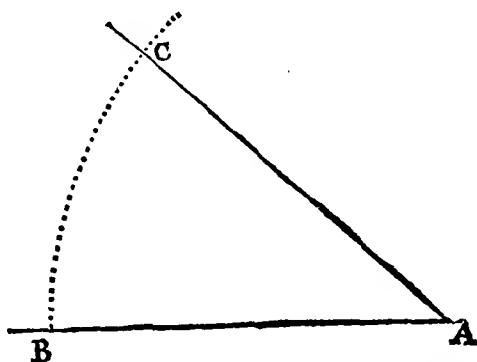
Suppose A B were a line given, and it were required to find how many Chains and Links are contained therein, according to the Scale of 10 in an Inch. Take in your Compasses the length of the line A B, and applying it to your Scale of 10 in an Inch, you shall find the extent of the Compasses to reach from 5 of the great divisions, to six of the lesser divisions, wherefore the line A B contains 5 chains and 60 Links: The like must be done for any line, and also by any of the other Scales.

Upon the Ruler there is (besides the several Scales of equal parts) a line or Scale of Chords, which is numbered by 10, 20, 30, &c. to 90, and this line serveth to protract or lay down angles; but in all the practice of Surveying a Protractor is much more convenient, yet for other uses this line may be very servicable, and when a Protractor is wanting, it may supply that defect: the manner how to use it is thus.

3 How to lay down upon paper, an angle containing any number of degrees and minutes by the line of Chords.

Draw a line as pleasure, as A B, and from the point A, let it be required to protract an angle of 40 degrees 20 minutes. First, extend your Compasses upon the line of Chords, from the beginning thereof to 60 degrees always, and with this distance, setting one

foot



foot upon the point A, with the other describe the pricked arch B C, then with your Compasses take 40 degrees 20 minutes (which is the quantity of the inquired angle) out of the line of Chords, from the beginning thereof to 40 degrees 20 minutes then (the Compasses so resting) if you set one foot thereof upon B the other will reach upon the arch to C. Lastly, draw the line A C, so the angle CAB shall contain 40 degrees 20 minutes

4 Any angle being given to finde what number of degrees and minutes are contained therein.

Suppose C A B were an angle given, and that it were required to finde the quantity thereof. Open your Compasses (as before to 60 degrees of your Chord, and placing one foot in A, with the other describe the arch C B, then take in your Compasses the distance C B, and measuring that extent upon the line of Chords from the beginning thereof, you shall finde it to reach to 40 degrees 20 minutes, which is the quantity of the required angle.

If any angle given or required shall contain above 90 degrees, you must then protract it at twice, by taking first the whole line, and then the remainder.

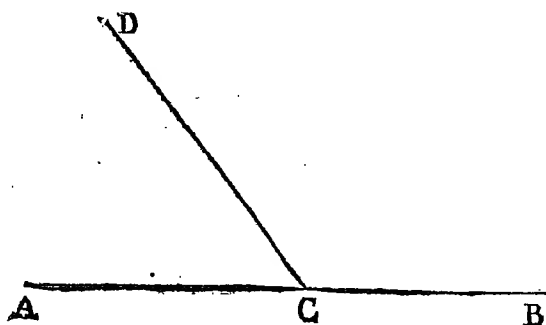
CHAP. II.

Of the use of the Protractor.

Although the chief uses of the Protractor may be performed by the line of Chords last spoken of, yet for avoiding superfluous lines and arches (which must otherwise be drawn all over your Plot) the Protractor is far more convenient, the use whereof is,

1 *To lay down upon paper an angle of any quantity.*

First, draw a right line at length as AB, then on any part thereof, as on C, place the center of the Protractor, in which point also fix your protracting pin, and turn the Protractor about upon the center, till the Meridian line of the Protractor (noted in the description thereof with E F) lie directly on this line AB, the Semicircle of the Protractor lying upwards (or from you) then close to the edge of the Semicircle, at the division of 50 degrees, mark the point D with your protracting pin; and draw the line CD, so shall the angle D C A, contain 50 degrees.



2 *Any angle being given, to find the quantity thereof by the Protractor.*

Suppose DCB were an angle given, and that it were required to find the quantity thereof by the Protractor. First, you must apply the center of the Protractor to the point C, and the Meridian line thereof directly upon the line DC, then shall you find the line CB to lie directly under 130 degrees of the Protractor, and such is the quantity of the angle D C B required.

CHAP. III.

Of the Plain Table, how to set the parts thereof together, and make it fit for the Field.

When you would make your Table fit for the field, lay the three boards thereof together, and also the ledges at each end thereof in their due places, according as they are marked. Then lay a sheet of white paper all over the Table which must be stretched over all the boards by putting on the Frame, which binds both the paper to the boards, and the boards one to another.

Then

Then screw the Socket on the back side of the Table, and also the Box and Needle in its due place, the Meridian line of the Card (which is in the Box) lying parallel to the Meridian or Diameter of the Table; which diameter is a right line drawn upon the Table from the beginning of the degrees through the center, and so to the end of the degrees. Then put the Socket upon the head of the Staffe, and there screw it. Also, put the sights into the Index, and lay the Index on the Table, so is your Instrument prepared for use as a Plain Table or Theodolite, the difference only being in placing of the Index, for when you use your Instrument as a Plain Table, you may pitch your center in any part of the Table, which you shall think most convenient for the bringing on of the worke which you intend: But if you use your Instrument as a Theodolite, then the Index must be turned about upon the Center of the Table, for which purpose there is a piece of wiew which goes through a small hole of brass fastened to the Index, and so into the center, by which means the Index keeps his constant place, only moving upon the center.

Your Instrument being thus ordered, you may use it either as a Plain Table or a Theodolite, but if you would use it as a Circumferentor, you need only screw the Box and Needle to the Index, and both of them to the head of the Staffe, with a brass screw-pin fitted for that purpose, so that the Staffe being fixed in any place, the Index and Sights may turn about at pleasure without moving of the Staff, and now is your Instrument a good Circumferentor, nay better then that before described in the second Book.

Also, when you have occasion to measure any Altitude, hang the Labell upon the farther Sight, and thus are you exactly fitted for all occasions.

CHAP. IV.

How to measure the quantity of any angle in the field, by the Plain Table, Theodolite, and Circumferentor: and also to observe an angle of Altitude.



You must understand that when I mention the Plain Table, or perform any work thereby, that I mean the Table when it is covered with a sheet of paper upon which, all observations of angles that are taken upon the Table in the field do agree exactly in proportion with those of the field it selfe, but are not denominated by their quantities, but by their symetry or proportion.

Secondly, when I mention the Theodolite, or work by that In-

Instrument, I do not mean the Theodolite before described in the 2 Chapter of the 2 Book, but I mean the degrees described on the frame of the Table, which supplies the use thereof.

Thirdly, When I mention or make use of the Circumferentor, I mean the Index with the Box and Needle screwed to the Staff.

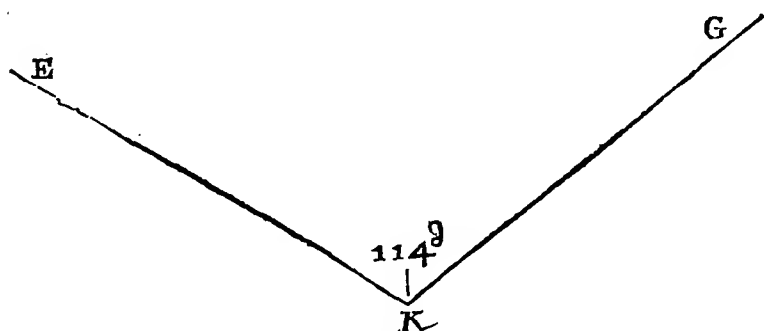
Having thus given you a sufficient description of the severall Instruments and their parts, I come now to the use of them, shewing how any angle in the field may be measured by any of them. And,

1. *How to observe an angle in the Field by the Plain Table.*

Suppose E K and K G to be two hedges, or two sides of a field including the angle E K G, and that it were required to draw upon your Table, an angle equal thereunto. First, place your Instrument as neer the angular point K, as conveniencie will permit, turning it about till the North end of the Needle hang directly over the Flower-de-luce in the Box, and then screw the Table fast. Then upon your Table, with your protracting pin or Compasse point, assigne any point at pleasure upon the Table, and to that point apply the edge of the Index, turning the Index about upon that point, till through the sights thereof you espie a mark set up at E, or parallel to the line E K, and then, with your protracting pin, or Compasse point, or Black-lead, draw a line by the side of the Index to the assigned point upon the Table. Then (the Table remaining immovable) turn the Index about upon the same point, and direct the sights to a mark set up at G, or parallel thereto, that is, so far distant from G, as your Instrument is placed from K, and then, by the side of the Index, draw another line to the assigned point, so shall you have drawn upon your Table two lines, which shall represent the two hedges E K and K G, and those lines shall include an angle equal to the angle, E K G, and although you know not the quantity of this angle yet you may (by the 1 or 2 Chapters of this Book) finde the quantity thereof if there were any need, for in working by this Instrument, it is sufficient only to give the symmetry or proportion of angles and not their quantities, as in working by the Theodolite or Circumferentor it is. Also, in working by the Plain Table, there needeth no protraction at all, for you shall have upon your Table the true figure of any angle or angles which you observe in the field, in their true positions, without any farther trouble.

2 *How to find the quantity of an angle in the field by the Theodolite.*

Let it be required to find the quantity of the angle E K G by the



the Theodolite: place your Instrument at K, laying the Index on the diameter thereof, then turn the whole Instrument about (the Index still resting on the Diameter) till through the sights you espie the mark at E, then screwing the Instrument fast there, turn the Index about upon the center, till through the sights you espie the mark at G, then note what degrees (on the frame of the Table) are cut by the Index, which you will finde to be 114 degrees, and that is the quantity of the angle E K G.

3 How find the quantity of any angle in the field by the Circumferentor.

If it were required to finde the quantity of the former angle E K G, by the Circumferentor; First, place your Instrument (as before) at K, with the Flower-de-luce, in the Card, towards you; then direct your sights to E, and observe what degrees in the Card are cut by the South end of the Needle, which let be 296, then turning the Instrument about the staff (the Flower-de-luce always towards you) direct the sights to G, noting then also what degrees are cut by the South end of the Needle, which suppose 182, this done (alwayes) subtract the lesser number of degrees out of the greater, as in this Example 182 from 296, and the remainder is 114 degrees, which is the true quantity of the angle E K G.

Again, the Instrument standing at K, and the sights being directed to E, as before, suppose that the South end of the Needle had cut 79 degrees; and then directing the sights to G, the same end of the Needle had cut 325 degrees, now, if from 325, you subtract 79, the remainder is 246, but because this remainder 246 is greater then 180, you must therefore subtract 246 the remainder, from 360, and there will remain 114, the true quantity of the inquired angle; and thus you must alwayes do, when the remainder exceedeth 180 degrees.

☛ This adding and subtracting for the finding of angles, may seem tedious to some; but here the Reader is desired to take

notice, that for quick dispatch the Circumferentor is as good an Instrument as the best, for in going round a field, or in Surveying of a whole Mannor, you are not to take notice of the quantity of any angle, but only to observe what degrees the Needle cutteth, which in those cases is sufficient, as will appear hereafter, but in taking of Distances by the Circumferentor it is altogether necessary, as may appear by the 7 Chapter following, and for that reason I have here shewed how to find an angle by the Circumferentor, and also that you might thereby perceive what congruity and harmony there is in all the three Instruments: but the Circumferentor is not a fitting Instrument for the taking of Distances.

4 *How to set the Index and Label Horizontal upon the Staff.*

When you have screwed the Index and sights to the Staff as a Circumferentor, before you put the Label upon the brass pin or wiew, you must hang a line and plummet upon that pin, and then put on the Label, then move the Index up and down till the third and plummet hang directly upon a line which is gaged from under the pin all along the Sight, and then doth the Instrument stand horizontal or level, which it must always do when you take an altitude therewith.

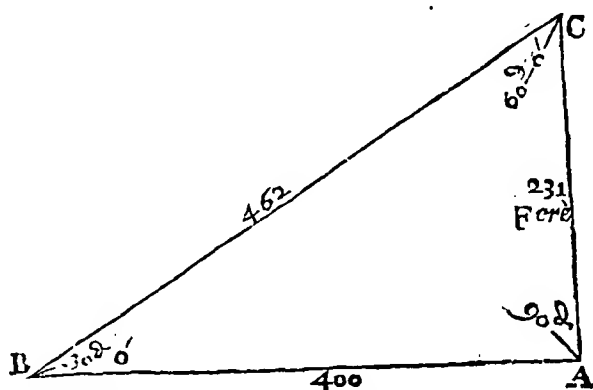
5 *How to observe an Angle of Altitude.*

The Label which is to be hanged on one of the Sights of the Circumferentor (as was intimated in the description thereof) and the Tangent line on the edge of the Index, is only for the finding of angles of altitude, and is therefore only useful in taking of heights, and in surveying of mountainous and un-even grounds.

The manner how to observe an angle of Altitude by this Label, and the Tangent line on the Index, is thus.

Suppose C A to be a Tree, Tower, or Hill, whose height were required. Your Instrument being placed at B, exactly level, direct the sights thereof towards C A, and there fix it, hanging the Label on the farthest sight, upon a pin for that purpose; then move the Label too and fro, along the side of the Index, till through the sight at the end of the Label, and by the Pin on, which the Label hangeth, you espy the very top of the object to be measured at C, then note what degree of the Tangent line is cut by the Label, which suppose 30, and that is the quantity of the Angle of Altitude, it being equal to the angle C B A.

Thus



Thus by the Rules in this Chapter delivered, may the true quantity of any angle be easily taken, and this is the most convenient use to be first placed, I will now shew how by your several Instruments you may take all manner of heights and distances, whether accessible or inaccessible, several wayes, with divers other necessary conclusions incident thereunto.

CHAP. V.

How to take an inaccessible Distance at two stations by the three fore-mentioned Instruments, and first by the Plain Table.



You are taught in the last Chapter how to make observation of any angle in the field by the several Instruments before mentioned, as the Plain Table, Theodolite, and Circumferentor, and also an angle of Altitude by the Index, and the Label thereunto annexed. I conceive it now convenient to shew how all manner of heights and distances may be readily and exactly measured, several wayes, whether they be accessible or inaccessible: and first of distances.

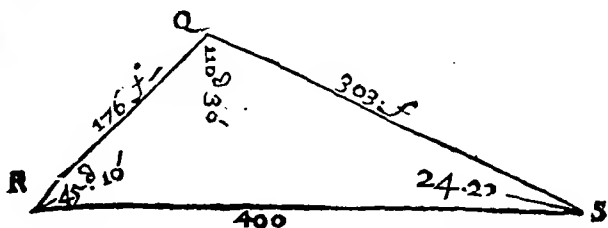
- ¶ You may remember that I formerly intimated, that the measuring of a Height or Distance is only to resolve a Triangle, so that when you make any observation either of Height or Distance, the observation of angles which you make are the angles of some Triangle, and the lines which you measure on the ground, are the sides of the same Triangle, and these are the given parts of the Triangle.

The manner how to take a distance by the Plain Table is thus, Suppose you were standing in a field at R, and that at S were some eminent mark, (as a Tree, Church, House, or such like) and that it were required to finde the distance between R and S.

First, place your Table at R, and thereon assigne any point at pleasure, unto which point apply the edge of your Index, turning it about upon that point, till through the sights you espie the mark at S, and draw a line by the side of the Index, as R S.

Then in some other convenient place of the field (as at Q) let a staffe or other mark be erected, and the Table remaining as before, turn the Index about, till through the sights you espie the mark at Q, drawing a line by the side thereof, as R Q, so have you described upon your Table an angle equal to the angle $\angle R S$. Then (with your Chain) measure the distance Q R, which let be 176 foot, then take with your Compasses 176 out of any Scale, and set it upon your Table from C to Q, so shall this point Q upon your Table, represent the mark at Q in the field.

This done, set up a staff at R, and remove your Table to Q, laying the Index upon the line Q R, and holding it fast there, turn the whole Table about till through the sights you espie the mark set up at your former place of standing at R: then screw the Table fast, and lay the Index on the point Q, turning it about, till through the sights you espie your mark at S, then draw a line by the side of the Index, which will cut the line R S (first draw) in the point S.



By this means shall you have upon your Table a Triangle equal to the Triangle QRS, the correspondent sides and angles thereof being proportionally equal with those in the field: therefore if with your Compasses you take the length of the side RS, & apply that distance to the same Scale from whence you took the side QR, you shall find it to contain 400 foot, and that is the distance between R and S. Likewise, if you take with your Compasses the length of the line QS, and apply it to the same Scale, you shall find it to contain almost 303, and so many foot is the distance QS.

¶ In this manner shall the distance between any two places be measured, although they be so situated, that by reason of water or other impediments you cannot approach neer unto. And here note, that when you take your second station, that you take it as large as the ground will permit, so shall your

your work be so much the truer, by now much the distance taken is the larger.

CHAP. VI.

How to take an inaccessible distance at two stations by the Theodolite.

IN the former Diagram, let R and Q be two stations, from either of which it is required to finde the distance to S.

First, place your Instrument at R, laying the Index and sights upon the Diameter thereof turning the whole Instrument about, till through the sights you espie your second station at Q, and there screw it fast, then turn the Index about upon the center, till through the sights you espy the mark at S, noting the degrees cut by the Index, which suppose 45 degrees 10 minutes. Then remove your Instrument to Q, laying the Index on the Diameter thereof, and holding it there turn the whole Instrument about, till through the sights you espie your mark at S, and fixing the Instrument there, turn the Index about till through the sights you see the mark set up at your former station at R, noting the degrees there cut, which let be 110 degrees 30 minutes. This done, measure the distance of your two stations QR, which let be 176 feet, so in the Oblique angled Triangle QSR, you have given, (1) the angle SRQ, 45 degrees 10 minutes, the angle observed at your first station. (2) the angle RQS, 110 degrees 30 minutes, which was the angle observed at your second station. And (3) you have given the side RQ 176 foot, which is the distance of your two stations: and you are to find the two other sides RS, and QS which you may find by the 7 Case of the 4th Chapter of the 3 Book, in this manner: for,

Having the two angles RQS and RQS given you have also the third angle RSQ given, 24 degrees 20 minutes, it being the complement of the other two to 180 degrees (by the 17th Chap. of the 3d, Lib. 3.) Then to find the other two sides, the proportion is;

I. For the side QS.

As the sine of the angle RQS, 24 degrees 20 minutes,
Is to the Logarithm of the side RQ 176 foot,
So is the sine of the angle QRS 45 degrees 10 minutes,
To the Logarithm of the side QS, 303 foot *sext*.

II. For the side RS.

As the sine of the angle QRS, 45 degrees 10 minutes,
Is to the Logarithm of the side QS, 303 foot,
So is the sine of the angle RQS 110 d. 30 min. (or 69 d. 30 m.)
To the Logarithm of the side RS, 400 foot.

Which is the distance required.

I have been larger upon this particular then I intended, having sufficiently insisted thereon before in the dimension of plain Triangles) but that the Reader may fully understand these necessary conclusions, I have in this example used all the perspicuity I could imagine, so that in the subsequent Chapters I may be the briefer, for this being well understood, he may easily apprehend any of the other at the first view.

CHAP. VII.

How to take an in-accessible distance at two stations by the Circumferentor.

Let it be required to find the distance from R and Q to S. First, place your Instrument at R, and direct the sights to S, observing what degrees the South end of the Needle cutteth, which let be 315 degrees 30 min. then turning the Instrument about, direct the sights to Q observing what degrees the Needle there cutteth, which let be 270 degrees 20 minutes, therefore from 315 degrees 30 minutes, subtract 270 degrees 20 minutes, and there will remain 45 degrees 10 minutes, which is the quantity of the angle S R Q.

Then remove the Instrument to Q, and direct the sights to R, the Needle cutting 91 degrees 00 minutes, also, direct the sights to S, the Needle cutting 340 degrees 30 minutes, now if you subtract 91 degrees 00 minutes, from 340 degrees 30 minutes, the remainder is 249 degrees 30 minutes, which because it exceedeth 180 degrees) subtract from 360 degrees, and there remains 110 degrees 30 min. the true quantity of the angle R Q S.

Having thus obtained the two angles R Q S and S R Q, you must measure the stationary distance QR 176 foot, so have you given in the Tringle QRS, (1) the angle R Q S 110 degrees 30 minutes, (2) the angle QRS, 45 degrees 10 minutes, (3) the angle QSR, 20 degrees 10 minutes, (the complement of the other) two to 180 degrees, and (4) the stationary distance QR 176 foot, whereby you may find the other sides QS and RS, according to the doctrine delivered in the foregoing Chapter.

	deg.	min.
First station at R, degrees cutteth	315	30
	270	20
The quantity of the angle QRS	45	10

	deg.	min.
Second Station at Q, degrees our	34	30
	91	00
	249	30
	460	00

The quantity of the angle RQS 100 30

The stationary distance 176 foot.

Having these things given, if you resolve the Triangle QRS, you shall find the side RS to contain 400 foot, and the side QS 303 foot *ferè*, as in the last Chapter.

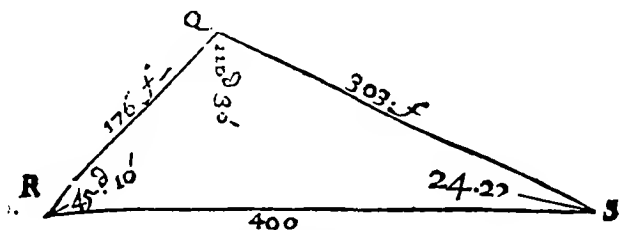
CHAP. VIII.

How to protract or lay down a Distance taken, according to the directions of the two last Chapters, upon paper, by help of your Protractor or line of Chords.

When you make any observations in the field, by the Theodolite or Circumferentor, you are to note down the quantities of the several lines and angles observed in the field, in a Book or paper, so that they may be ready at hand when you come to protraction, and this is the usual way.

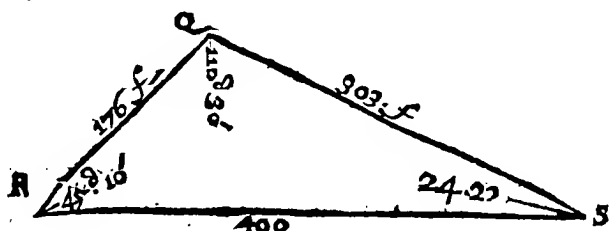
Suppose it were required to draw upon paper or parchment the true symetry or proportion of the distance taken in the last Chapter.

First, upon your paper draw a line at length as RQ, then, upon one end thereof, as at R, place the center of your Protractor, and lay the Meridian line EF of the Protractor, directly upon the line



QR: then, (because the angle QRS is 45 degrees 10 minutes, therefore, against 45 degrees 10 minutes of your Protractor, make a mark upon your paper with your protracting pin (as is before taught Chap. 2.) and draw the line RS. This done, from any Scale, take

take your stationary distance R Q 176 foot, and set it from R to Q. Then upon the point Q (because the angle R Q S contains 110 degrees 30 minutes) place the center of the Protractor, and turn it about till the line R Q lie directly under 110 degrees, then (at the point E of the Protractor) make a mark with your protracting pin, and through that point draw the line Q S, which will cut the line R S in the point S: then if you measure the length of the lines Q S and R S; by the same Scale from whence you took 176 for the line Q R, you shall find the line Q S to contain 303, and the line R S to contain 400, exactly agreeing with the numbers found in the last Chapter.



CHAP. IX.

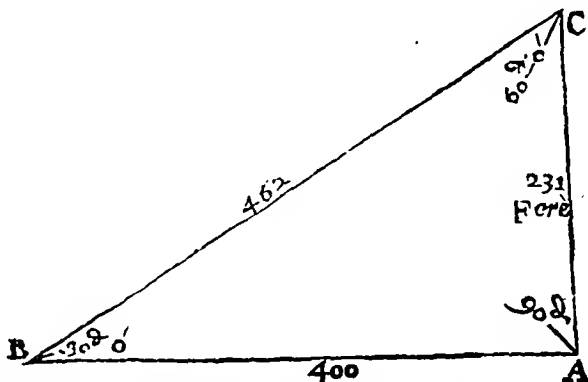
How to take the altitude of any Tower, Tree, Steeple, or the like (being accessible) by the Label and Tangent Line.

HAVING in the fifth Section of the fourth Chapter of this Book, shewn how to observe an angle of Altitude by the Label and Tangent Line, we now come to the further use thereof.

Suppose therefore that the line C A were a Tree, Tower, Steeple, or other thing, whose height were required.

First, place your Instrument at any convenient distance from the Base or foot of the object to be measured, as at B, and there looking through the sights of the Label, till you espy the top of the Altitude at C, note what degrees of the Tangent Line is cut by the Label, for that is the quantity of the angle of Altitude, namely, the angle C B A, which suppose 30 degrees: then is the other angle B C A 60 degrees, it being the complement of the former to 90 degrees.

Then



Then (with your Chain or otherwise) measure the distance from B (the place of your standing) to A, the foot of the thing to be measured, which suppose 400 foot: Then in the Triangle A B C, there is given (1) the angle C B A 30 degrees, (2) the angle B C A, 60 degrees, and (3) the distance B A 400 foot, and it is required to find the side C A, by the 1 Case of right angled plain Triangles: For,

As the sine of the angle B C A, 60 degrees,
Is to the Logarithm of the side B A 400 foot;
So is the sine of the angle C B A 30 degrees,
To the Logarithm of the side C A.

This proportion being wrought according to the former directions, the side C A will be found to contain almost 231 foot, and that is the height of C A required.

CHAP. X.

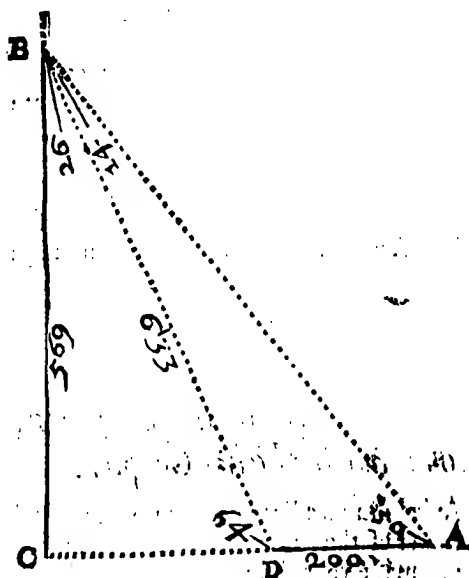
How to protract or lay down upon paper, the observation made in the last Chapter.

HAVING drawn a line upon your paper as B A, place the center of the Protractor upon B, now (because when you made your observation at B, the degrees cut were 30) turn the Protractor about till the line B A lie just under 30 degrees, then (with your protracting pin) make a mark by the edge of your Protractor against 90 degrees, & draw the line B C. so shall the angle C B A contain 30 deg^r. Then (because the measured distance B A was 400 foot,) take 400 from any of your Scales of equal parts, and set that distance from B to A and from the point A, erect the perpendicular A C, which perpendicular being taken in your Compasses, and measured upon the same Scale from whence the 400 foot was taken, you shall find it to contain almost 231 foot, and so much is the altitude C A as before.

CHAP. XI.

How to take an inaccessible Altitude, by the Label and Tangent line,

OR the effecting hereof you must make two observations with your Instrument. Let the line BC in this figure represent some Object whose height is required: First, place your Instrument at A , and direct the sights to B , the top of the object, noting what degrees of the Tangent line are cut by the Label, which let be 50 degrees, the quantity of the angle BAC . Now, because you cannot come to measure the distance from A to C , by reason of some River or other impediment lying between A and C , therefore, with your Chain, measure out from A towards C , any number of feet, according as the ground will permit, as from A to D , which suppose to be 200 foot, and at D , place



your Instrument again, and there observe the quantity of the angle BDC , which suppose to be 64 degrees, these two angles being known, the two opposite angles are also known, for the angle BAC being 50 degrees, the whole angle ABC must be 40 degrees, the complement of the former to 90 degrees; again, the angle BDC being 64 degrees, the angle DBC must be the complement thereof, namely 26 degrees, then if you subtract the angle DBC 26 degrees, from the whole angle ABC 40 degrees, there will remain 14 degrees for the angle ABD , by the knowledge whereof you

ma

may attain the altitude B C; for, in the Triangle A B D you have given,

- 1 The angle B A D, 50 degrees,
- 2 The angle A B D, 14 degrees,
- 3 The distance A D 200 foot.

Which (by the former directions) will help you to finde the length of the side D B, either by the Tables in the 5 *Book*, or by the Lines of artificial Numbers, Sines and Tangents on the Index of your Table, as is formerly taught, the proportion being,

As the sine of the angle A B D, 14 degrees,
Is to the Logarithm of the side A D, 200 foot;
So is the sine of the angle B A D, 50 degrees,
To the Logarithm of the side D B.

Which by working according to the former direction, will be found to be 633 foot.

Then must you make a second work in the Triangle B C D, in which you have given,

- 1 The angle B D C, 64 degrees,
- 2 The angle D B C 26 degrees,
- 3 The side D B, 633 foot,


And you are to find the side of B C, the altitude required, wherefore say again,

As the sine of the angle B C D, 90 degrees,
Is to the Logarithm of the side D B 633 foot;
So is the sine of the angle B D C 64 degrees,
To the Logarithm of the Altitude B C:

Which according to the former Doctrine will be found to be 569 foot.

CHAP. XII.

How to Protract the observation taken in the last Chapter.

HEN you have made your observation as in the last Chapter, and noted down in a Book or otherwise, that the degrees cut your first station at A were 50, and the degrees cut at the second station at D were 64, and that your stationarie distance A D was 200 foot, you may immediately find the Altitude B C by protraction, thus,

First, draw a line as A C, in which line let A represent your first station, whereon lay the center of your Protractor, and make the angle B A C to contain 50 deg. (as hath been several times be-

C c

fore

fore shewn:) and draw the line AB. Then upon the line AC set off the distance of your two stations 200 foot from A to D, then bring your Protractor to D (which represents your second station) and placing the center of your Protractor thereupon, set off an angle of 64 degrees, as BDC, and draw the line DB then where these two lines AB and DB intersect or meet, which is in the point B, from that point let fall the perpendicular BC, the length whereof being measured upon the same Scale from whence you tooke the distance AD, will give you 569 foot, and that is the altitude of AB, which was required.

CHAP. XIII.

How to take the distance of divers places one from another, according to their true scituation, in Plano, and to make (as it were) a Map thereof, by the Plain Table.

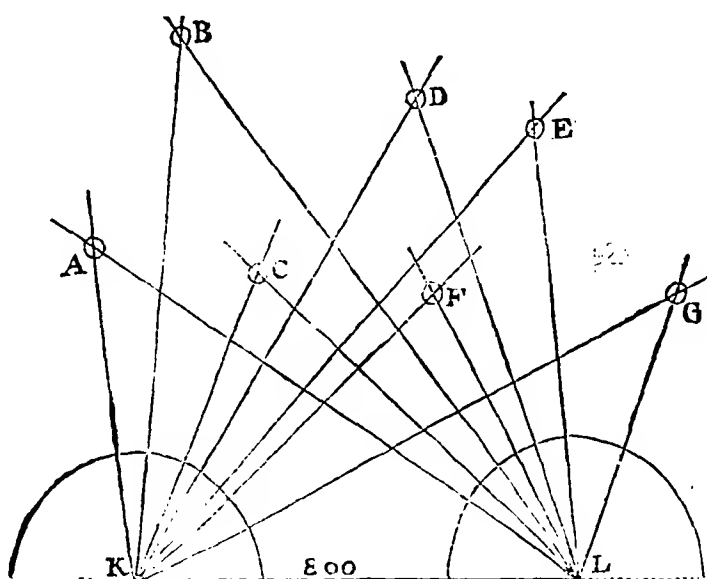


His Proposition is of good use to describe in *plano* the most eminent places in a Town or City, and to make (as it were) a Map thereof. Let ABCDEFG. be certain eminent places scituate in some Town or City, and let it be required to describe all those places upon paper, by which distance of any of them one from another, may be readily found.

At some convenient distance from the City, Town, or Field, make choice of two other convenient places as K and L, from either of which you may plainly discern all the marks which you intend to describe in your Map. Then, at one of these places, (as at K) place your Table and neere one of the sides thereof draw a line parallel to the edge of the Table; In this line assigne any point as K for your first station, and laying the Index upon this line, turn the Table about, till through the sights you espie the other place which you intend for your second station, which found, screw the Table fast there.

Then laying the Index to the point K, turn it about, till through the sights you espie your first mark at A, and by the side of the Index draw the line AK. Secondly, turn the Index to the second mark at B, and draw the line BK. Thirdly, direct your sights to C, and draw the line CK. Fourthly, direct your sights to D, and draw the line DK. Fifthly, direct the sights to E, and draw the line EK. Sixthly, direct the sights to F, and draw the line KF. Lastly, direct the sights to G, and draw the line KG, so have you finished your work at your first station.

This



This done, with your Chain, measure the distance of your two stations K and L, which suppose to contain 800 foot, and removing yett Table to L, lay the Index upon the line KL, turning the Table about till through the sight you see your first station at K, and there screw it fast so that it alter not so long as your work continueth.

Then laying the Index to the point L, direct your sights to the several marks as before, namely, to A C B F D E G, and from each of those marks draw lines by the side of the Index, as AL, CL, BL, FL, DL, EL, and GL, so is your work finished at your second station also.

Having thus done, first observe where the line KA crosseth the line LA, which is at A, at which point you may draw the figure or write the name of the thing which it representeth. Secondly, observe where the line KB crosseth the line LB, which is at B, at which point write the name of the place as before. Thirdly, observe where the lines KC and LC intersect, which is at C, at which point also note the place, Fourthly, at the intersection of KD and LD which is at D, write the name of the place as before.

Do thus with all the rest of the places be they never so many, so shall the several points of intersection A B C D E F G upon your Table, represent the respective places in the Town or City.

Now to know the distance of any of these places one from another, you must take the distance required in your Compasses, and apply it to the same Scale by which the stationarie distance KL was laid down, and it will there shew you the distance required.

CHAP. XIV.

How to performe the work of th. last Chapter by the Theodolite.

IN the last Chapter, make choice of two places, from either of which you may conveniently see all those Marks which you intend to describe, which two places let be K and L. Then placing the Instrument at K, lay the Index on the Diameter thereof, and turn the whole Instrument about till through the sights you espie your second station at L: then fixing the Instrument there, direct your sights to the several marks A B C D E F G, observing what degrees the Index cutteth when directed to any of the marks intended. As, suppose, your Instrument being fixed at K, and the sights directed to A, the Index cuts 83 degrees 50 minutes; at B, 97 degrees 55 minutes; at C, 114 degrees 10 minutes; at D, 123 degrees 40 minutes; at E, 134 degrees 35 minutes; at F, 138 degrees 30 minutes; and at G, 155 degrees, 20 minutes.

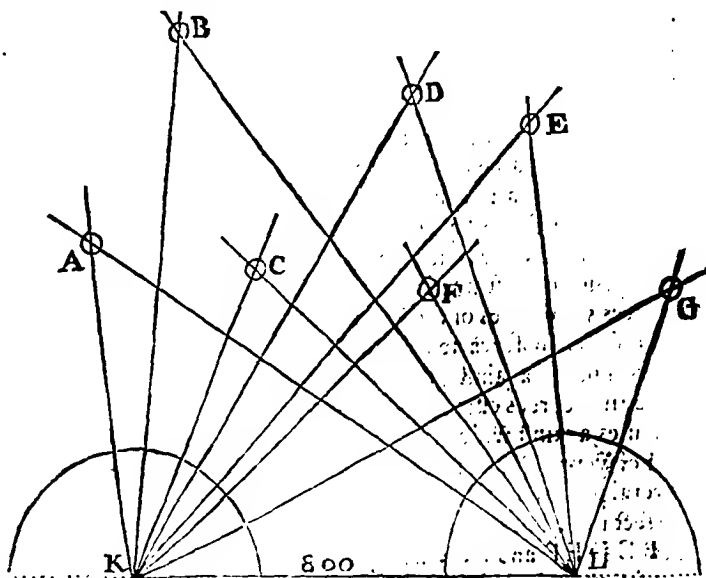
Then removing your Instrument to L, lay the Index on the Diameter thereof, and turn it about till through the sights you espie your former station at K, as is before taught: Then directing the sights to your first mark A, the Index cuts 33 degrees 50 minutes; at B, 43 degrees 40 minutes; at C, 54 degrees 10 minutes; at D, 64 degrees; at E, 73 degrees 20 minutes; at F, 87 degrees 15 minutes; and at G, 113 degrees 40 minutes.

These several observations of the degrees cut by the Index at both stations, ought to be noted in a Book or paper, together with the stationarie distance, as in this example.

	deg.	min.
First station	A	83 50
	B	97 55
	C	114 10
	D	123 40
	E	134 35
	F	138 30
	G	155 20

The Stationarie distance 800 Foot.

Second station	A	33 50
	B	43 40
	C	54 10
	D	64 00
	E	73 20
	F	87 15
	G	113 40



By help of this Table of your observations, you may at any time protract the same upon paper, and making a Scale of equal parts answerable to the parts of your stationary distance, you may with your Compasses measure the distance of any of these marks or places one from another, or from either of your stations.

CHAP. XV.

How to protract the former Observations upon Paper, and to make a Scale to measure any of the Distances.



Our paper or parchment being provided, draw thereupon a line at length, and therein assigne two points as K and L, representing your two stations, then upon your first station at K, lay the Center of your Protractor, with the Meridian line thereof (which is noted with E F) directly upon the line KL. Then lay the Table of your observations before you, and seeing that at your first observation the Index cut 83 degrees 50 minutes, you must therefore with your protracting pin make a mark against 83 degrees 50 minutes of your Protractor. Again, seeing that at your second observation the Index cut 97 degrees 55 minutes, therefore, with your protracting pin, make a mark upon your paper, against 97 degrees 55 minutes of your Protractor. And thirdly, seeing that at your third observation your Index cut 114 degrees 10 minutes, you must likewise make a mark against 114 degrees 10 minutes,

and

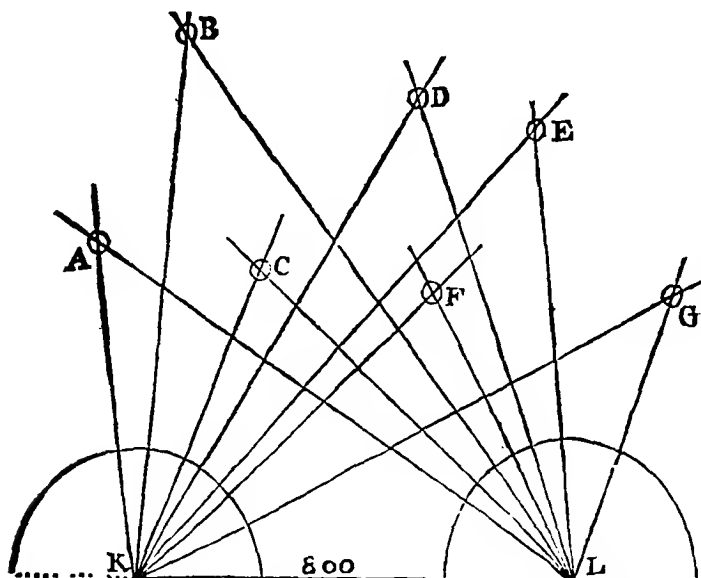
and thus must you do with all the rest of your observations, be they never so many. Which being done, from the point or station K, you must draw the straight lines K A, K B, K C, K D, &c.

Then remove your Protractor to L, which signifies your second station, laying the Meridian line thereof upon the line K L, and then by your Table, note the angles of your observations made at your second station in all respects as you did those of your first station: so shall you find that at the first observation at your second station, the Index cut 33 degrees 50 minutes, therefore, with your protracting pin make a mark upon the paper against 33 degrees 50 minutes of the Protractor. Again, the degrees cut at your second observation were 43 degrees 40 minutes, therefore make a mark against 43 degrees 40 minutes of your Protractor. Also, the degrees cut at your third observation were 54 degrees 10 minutes, against which likewise make a mark, dealing with all the rest of your observations in the same manner: then through these several points, from your station L, draw straight lines till they intersect those lines before drawn from K, which will be the points A B C D E F and G, which points bear a just proportion to the Marks which you observed.

Now to find the distance of any of these marks one from another, you must divide a line into such equal parts, so that your stationarie distance K L may contain 800 of them. Your Scale being thus made, take in your Compasses the distance between any two marks or places here described, and apply it to your Scale so shall it exactly shew you the true distance between the two places so taken, in the same parts as the line K L was divided.

In this manner may you with speed and exactness attain the true distance and situation of any Mark or Marks far remote, without approaching neer any of them: and thus in over-grown land, where you can neither go about it, nor measure within it, this Chapter will be of excellent use.

¶ I might here insert divers other Cases concerning the taking of Heights and Distances; as, divers places lying in the same right line to find their distance; or, part of a Distance or Altitude being given, to find the whole, with infinite other of that nature, but seeing that these are but parts or branches of what is here delivered, and are rather Problemes of curiosity then use, I will therefore passe them over, and the rather, because these being rightly understood, the performance of any other will be very easie. But remember alwayes in taking of inaccessible Heights and Distances, as also in the plotting of un-passeable grounds, that you take this your stationarie distance as as may be. And if at any time you be required to the altitude of a Castle, Church or Tree, standing on a Hill, you must perform it at two operations, first, by taking the altitude of the Castle and Hill together as one altitude, and secondly, by taking the height of the Hill alone; then by



by subtraſting the height of the Hill from the whole height, the remainder ſhall be the height of the Caſtle. And here note alſo, that in the taking of all manner of Altitudes, whether acceſſible or inacceſſible, you muſt alwayes adde the height found, the height of your Inſtrument from the ground.

CHAP. XVI.

How to take the true plot of a field at one ſtation taken within the ſame field, ſo that from thence you may ſee all the angles of the ſame field by the Plain Table.

WHen you enter any field to ſurvey, your firſt work muſt be to ſet up ſome viſible mark at each angle thereof, or let one go continually before you to every angle, holding up a white cloth, or the like, to direct you: which being done, make choice of ſome convenient place about the middle of the field, from whence you may behold all your Marks, and there place your Table covered with a ſheet of paper, the needle hanging directly over the Meridian line of the Card (which you muſt alwayes have regard unto, eſpecially when you are to ſurvey many fields together). Then make a marke about the middle of your paper, which ſhall repreſent that part of the field where your Table ſtanderth, and laying the Index unto this point, direct your ſights to the ſeverall angles where you before placed your marks, and draw lines by the ſide of the Index

Dd

upon

upon the paper; then measure the distance of every of these marks from your Table, and by your Scale set the same distances upon the lines drawn upon the Table, making small marks with your Protracting pin or Compasse point at the end of every of them; then lines being drawn from one to another of these points, you shall have upon your Table the exact plot of your Field, all the lines and angles upon the Table being proportional to those of the Field.

Suppose you were to take the Plot of the Field A B C D E F. Having placed marks in the several angles thereof, make choice of some convenient place about the middle of the Field, as at L, from whence you may behold all the marks before placed in the several angles, and there place your Table, then turn your Instrument about, till the needle hang over the Meridian line of the Card, the North end of which line is noted with a Flower-de-luce, and is represented in this figure by the line N S.

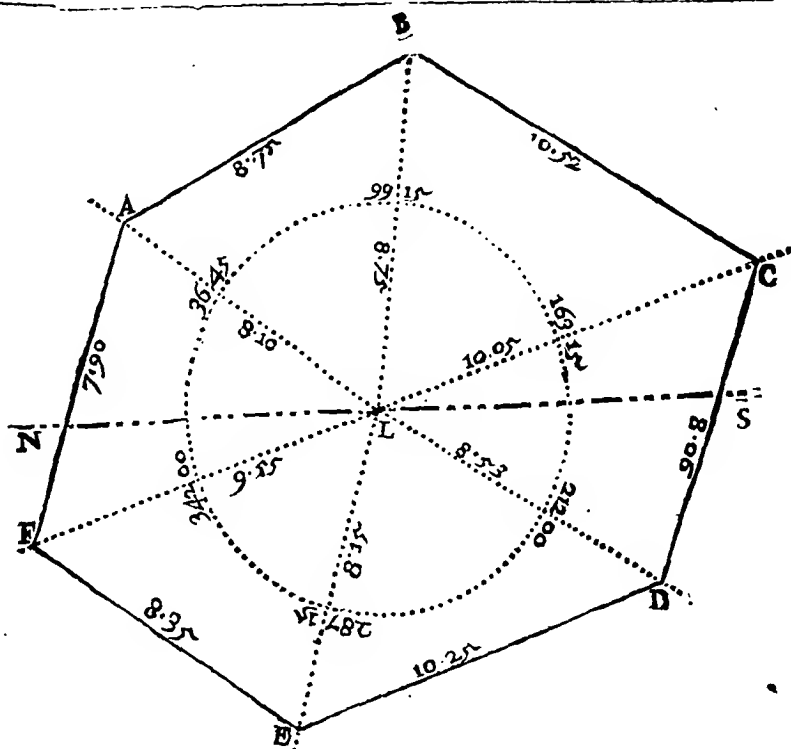
Your Table being thus placed, with a sheet of paper thereupon, make a mark about the middle of your Table which shall represent that place in the field where your Table standeth: then, applying your Index to this point, direct the sights to the first mark at A, and the Index resting there, draw a line by the side thereof to the point L, then with your Chain measure the distance from L, the place where your Table standeth, to A your first mark, which suppose to be 8 Chains 10 Links, then take 8 Chains 10 Links from any Scale, and set that distance upon your Table from L to A, and at A make a mark.

Then directing the sights to B the second mark, draw a line by the side of your Index as before, and measure the distance from your Table at L, to your mark at B, which suppose 8 Chains 75 links, this distance must be taken from your Scale, and set upon your Table from L to B, and at B make another mark.

Then direct the sights to the third mark C, and draw a line by the side of the Index, measuring the distance from L to C, which suppose 10 Chains 65 links; this distance being taken from your Scale and applied to your Table from L to C, shall give you the point C, representing your third mark.

In this manner you must deal with the rest of the marks at D E and F, and more, if the field had consisted of more angles.

Lastly, when you have made observation of all the marks round the Field, and found the points A B C D E and F upon your Table, you must draw lines from one point to another till you conclude where you first began: as draw a line from A to B, from B to C, from C to D, from D to E, from E to F, and from F to A, where you began: then will A B C D E F be the exact figure of your field, the sides and angles of the said figure bearing an exact proportion to those in the Field, and the line N S, in this and the following figures, always representeth the Meridian line.



CHAP. XVII.

How to take the plot of a field at one station taken in the middle thereof by the Theodolite.

Place marks at the several angles of the field as before and make choice of some convenient place about the middle thereof, as L, from whence you may see all the marks, and there place your Instrument, the Needle hanging directly over the Meridian line in the Card.

This done, direct your sights to the first mark at A, noting what degrees the Index cutteth, which let be 36 degrees 45 minutes, these 36 degrees 45 minutes must be noted down in your field-book in the first and second Columns thereof. Then measure the distance from L the place of your Instrument, to A your first mark, which let contain 8 Chains 10 Links, these 8 Chains 10 Links must be placed in the third and fourth Column of your field-book, as hath been directed in the description thereof.

Then direct the sights to B your second mark, and note the degrees cut by the Index, which let be 99 degrees 15 minutes, and the distance L B 8 chains 75 links, the 99 degrees 15 minutes must be noted in the first and second Columns of your field-book, and the 8 Chains 75 Links in the third and fourth Columns.

Then direct your sights to C, your third mark, and note the degrees cut by the Index, which let be 163 degrees 15 minutes, and let the distance LC be 10 Chains 65 Links; the 163 degrees 15 minutes must be noted in the first and second columns of your field book, and the 10 Chains 65 Links in the third and fourth columns thereof.

Then direct your sights to D, your fourth mark, and note the degrees cut by the Index; which let be 212 degrees:

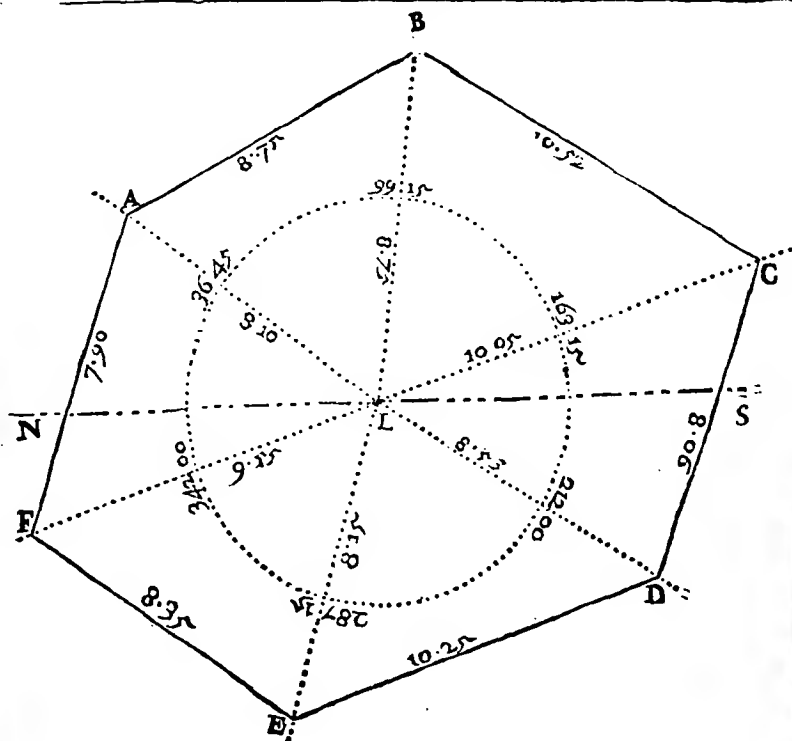
And here you must note that in using the degrees on the frame of the Table, that after the Index hath passed 180 degrees, which is at the line N S (representing always the Meridian line) you must then count the degrees backward; according as they are numbered on the frame of the Table from 190 to 360.

Then measure the distance LD, which let be 8 Chains 53 Links; the 212 degrees must be noted in the first Columns of your field-book, and the 8 Chains 53 Links in the third and fourth Columns thereof.

Then direct your sights to E, the Index cutting 287 degrees 15 minutes, and the distance LE being 8 Chains 15 Links, these must be noted in your field-book as before, the 287 degrees 15 minutes in the first and second columns, and the 8 Chains 15 Links in the third and fourth.

Lastly, direct the sights to F, your last mark, the Index cutting 342 degrees, and the distance LF being 9 Chains 55 Links, these must be noted down in your field-book in all respects as the former, viz. the 342 degrees in the first column, and the 6 Chains 55 Links in the third and fourth: then will your observations noted in your field-book stand as in this Table following.

	Degrees	Minutes	Chains.	Links
A	36	45	8	10
B	99	15	8	75
C	163	15	10	65
D	212	00	8	53
E	287	15	8	15
F	342	00	9	55



CHAP. XVIII.

How to take the plot of a Field at one station taken in the middle thereof by the Circumferentor.

Here is little difference between the work of this and the last Chapter: for, the marks being placed in the several angles of the field, and the station appointed at L, place there the Instrument, and turning it about, direct the sights to A (the Flower-de-luce of the Card being alwayes towards you) the South end of the Needle cutting 36 degrees 45 minutes the same which the Index of the Theodolite did in the last Chapter, then measuring the distance from L to A, you will finde it to contain, as before, 8 Chains 10 Links, which you must note down in your field-book as in the last Chapter.

Then turning the whole Instrument about (as before) direct the sights to B, the South end of the Needle cutting 99 degrees 15 minutes, and the distance L B will contain 8 Chains 75 Links, which note down in your Book also.

In this manner must you direct the sights to all the other angles C D E and F, and you shall finde the South end of the Needle

al-

alwayes to cut the same degrees in the Card as the Index of the Theodolite did, and the measured lines L C, L D, L E, and L F, will be likewise the same, so that the Table of observations in the last Chapter will serve to protract either this or the other work, as is taught in the next Chapter.

CHAP. XIX.

How to protract any observations taken according to the directions in the last Chapter.

First, draw upon your paper or parchment a line at length, which shall represent the Meridian lines N S in the figure, then make choice of some point or other in that line which shall represent your station or place of standing in the field, as K: upon this point place the center of your Protractor, so that the Meridian line E F of the Protractor, may lie directly upon the Meridian line N S of this figure.

Then laying your field-book before you; seeing that at your first observation at A, the Index of the Theodolite, or the Needle of the Circumferentor, cut 36 degrees 45 minutes, you must therefore against 36 degrees 45 minutes of your Protractor make a mark upon your paper.

2 Seeing the degrees cut at your second observation were 99 degrees 15 minutes, you must mark upon your paper against 99 degrees 15 minutes of your Protractor.

3 The degrees cut at your third observation were 165 degrees 15 minutes, therefore against 163 degrees 15 minutes make a mark upon your paper.

4 The degrees cut by the Index or Needle at your fourth observation being 212 degrees ==

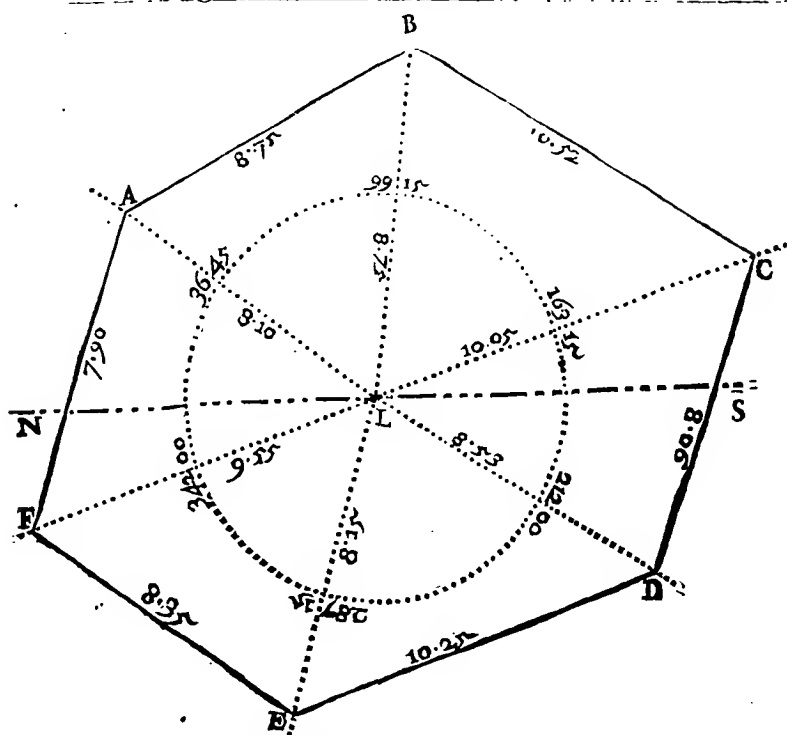
Now because 212 degrees is greater then 180 degrees you must therefore turn the Semicircle of the Protractor downwards, yet the line E F thereof must lie directly upon the Meridian line N S, as before.

==you must against 212 degrees of the Protractor make a mark upon your paper.

5 Seeing the degrees cut at your fifth observation were 287 degrees 15 minutes: therefore make a mark against 287 degrees 15 minutes of the Protractor.

Lastly, the degrees cut at your last observation were 342, therefore against 342 degrees of your Protractor make a mark with your Protracting pin, as before.

Having thus protracted all the degrees of your several observations, take away your Protractor, and laying a ruler to the point L, draw



draw obscure lines from L through those points, which lines will be L A, L B, L C, L D, L E, and L F.

This done, you must observe by your field-book the length of every line

As the line L A at your first observation was 8 Chains 10 Links, therefore, 8 Chains 10 Links being taken from your Scale and set upon your paper from L to A, it shall give you the point A upon your paper.

2 The length of your second line being 8 Chains 75 Links, you must take 8 Chains 75 Links from your Scale, and set it upon your paper from L to B.

3 The line L C being 10 Chains 65 Links, you must therefore take 10 Chains 65 Links from your Scale, and set it upon your paper from L to C.

And thus must you deale with all the rest of the lines, as L D, L E, and L F.

Lastly, draw the lines A B, B C, C D, D E, E F, and F A, so shall you have the exact figure of the field upon your paper.

¶ In these four last Chapters you are taught how to take the plot of any field at one station taken in the midst thereof, both by the Plain Table, Theodolite, and Circumferentor, and also how to protract the same. This way of plotting of a field is seldome; or never, used in surveying of divers parcels, but for

for one particular field it is as good as any, but divers other varieties will appeare in the following Chapters.

CHAP. XX.

How to take the plot of a Field at one station taken in any angle thereof, from whence all the other angles may be seen, by the Plain Table.

PLace your Table in some convenient angle in the field to be measured, and turn it about till the Needle hang directly over the Meridian line in the Card, and there fix it: then draw a line parallel to the side of your Table, as N S: in which line assigne any point at pleasure, as H, which shall represent your station or place of standing, unto this point apply the Index, and direct the sights to A and draw a line upon your paper as H A; and measure the distance H A (as was directed before in Chap. 16.) Then direct the sights to B, your second mark, and there likewise draw a line H B, measuring the distance A B, as was taught in the fore-mentioned Chapter.

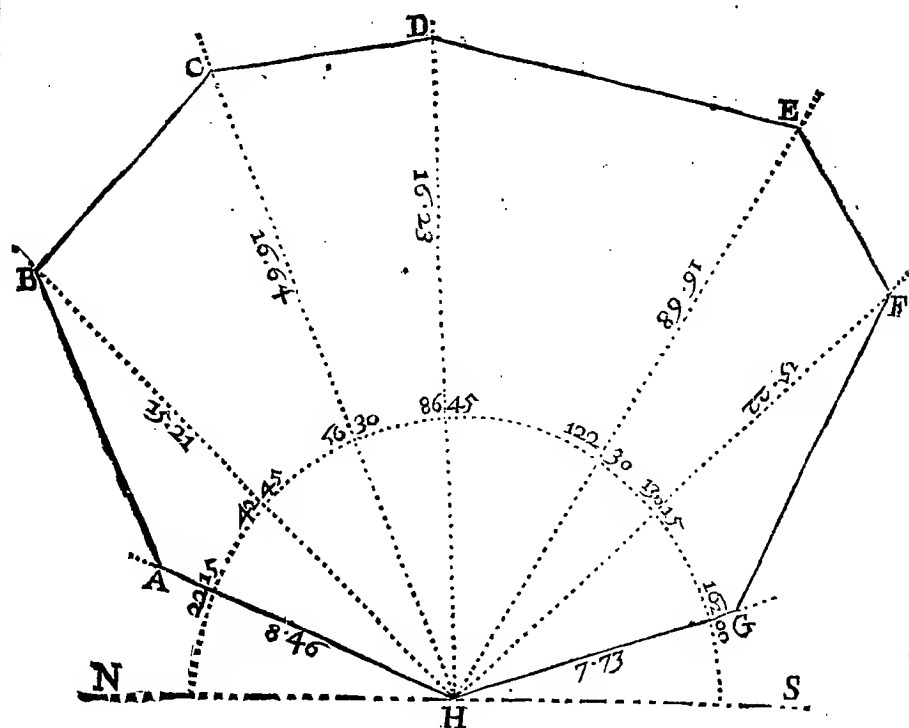
In like manner direct the sights to C D E F and G, drawing lines by the side of your Index at every observation, and measure with your Chain the distance from H (the place where your Instrument standeth) to the severall angles of the field A, B, C, D, E, F, and G, which distances being taken in your Compasses, from any Scale, and set upon your Table from H upon the severall lines H A H B, H C, H D, H E, H F, and H G, so shall you have upon your Table the points A, B, C, D, E, F, and G, by which marks draw the lines H A, A B, B C, C D, D E, E F, F G, and G H, which lines will include the exact figure of the field upon your Table.

CHAP. XXI.

How to take the plot of a Field at one station taken in any angle thereof by the Theodolite.

IN the same figure following, having placed your Instrument at H, as is taught in the fore-going Chapter direct the sights to A, your first mark, noting the degrees cut by the Index, which suppose 22 degrees 15 minutes, these degrees and minutes must be noted in the first and second columns of your field-book (as hath been before sufficiently taught.) Then with your Chain measure the distance from your station at H to the angle A, which let be 8 Chains 46 Links, which you must place in the third and fourth columns of your field-book, according to the former directions.

2. Direct



2 Direct your sights to B noting the degrees there cut, which suppose 42 degrees, 45 minutes, these degrees and minutes place in the first and second Columns of your field-book, and measure the distance H B, 15 Chains 21 Links, and note them down in the third and fourth Columns thereof.

3 Direct your sights to C, the degrees cut being 68 degrees 30 minutes, and the distance H C 16 Chains 64 Links, note these also in your field-book as before.

And in this manner must you deal with the other marks D, E, F, and G, so having noted them all in your field-book they will stand as followeth.

	Degrees	Minutes	Chains	Links
A	22	15	8	46
B	42	45	15	21
C	66	30	16	64
D	86	45	16	23
E	122	30	16	68
F	130	15	15	22
G	162	00	7	73

CHAP. XXII.

How to take the Plot of a Field at one station taken in any angle thereof, from which all the rest may be seen by the Circumferentor.

PLace your Instrument at H, and direct the sights to A (observing the cautions formerly delivered in the use of this Instrument) the Needle cutting 22 deg. 15 min. and the distance H A containing 8 Chains 46 Links, which agrees exactly with the first observation in the last Chapter: these degrees and minutes, together with the measured distance H A must be noted down in the several Columns of your Field-book, and if you make observation round about the field, from angle to angle, and measure the length of every line from H, to B C D E F and G, you shall finde the degrees cut by the Needle, to be the same with those (in the last Chapter) cut by the Index, and the measured distances to be likewise equall: and if you make a Table of your observations, you shall finde it the same with that in the last Chapter.

CHAP. XXIII.

How to Protract any observation taken according to the Doctrine of the two last Chapters.

First, draw the meridian line N S, and make choice of a point therein representing your stationarie angle, as at H, to which point apply the center of your Protractor, the Semicircle upwards. Then laying your Field-book before you, you may perceive that at your first observation (which was at A) the Index of the Theodolite, or the Needle of the Circumferentor cut 22 deg. 15 minutes, therefore make a mark against 22 degrees 15 minutes, & draw the line H A.

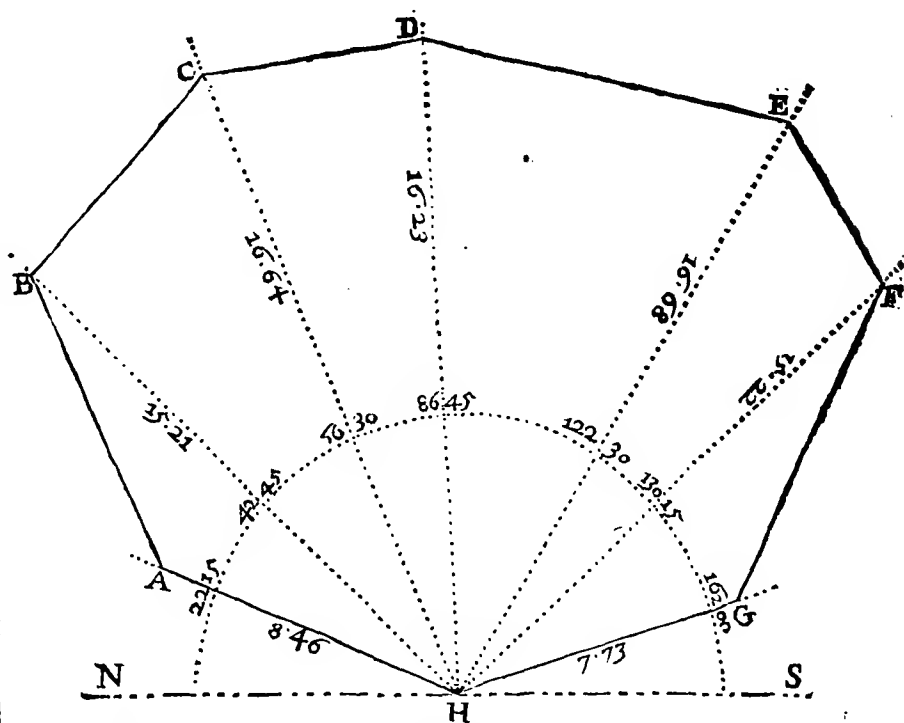
2 The degrees cut at your second observation at B, being 42 deg. 45 minutes, make a mark likewise against 42 degrees 45 minutes of your Protractor, and draw the line H B.

3 The degrees cut at your third observation being 66 deg. 30 min. make a mark against 66 deg. 30 min. and draw the line H C.

And in this manner must you proceed with the rest of your observations, D, E, F, and G.

Having thus protracted your angular observations, proceed now to your lineall, namely, to the length of your lines, noted in the third and fourth Columns of your Field-book.

1 Seeing that the length of your first line H A was 8 Chains 46 Links, you must take 8 Chains 46 Links from your Scale, and apply it to your paper from H unto A.



2 The length of your second line H B, being 15 Chains 21 Links take 15 Chains 21 Links from your Scale, and apply that distance to your paper from H unto B.

3 The distance of your third mark H C being 16 Chains 64 Links, take that distance from your Scale, and apply it to your paper from the point H unto C.

In all respects as before, you must proceed with the measuring of all the other lines about the field, were they never so many.

Lastly, if from these point A B C D E F G, and H, you draw the line A B, B C, C D, D E, E F, F G, and G H, you shall have upon your paper the exact figure of your field.

☛ And herein you may receive abundant satisfaction, to see your several Instrumental operations, and your Geometricall protraction so exactly to agree: and if at any time you make severall observations of any one piece of ground, according to the directions of the foregoing Chapters, or the like, if you finde them not exactly to agree, you may be sure you have failed in one or other of your observations, and therefore, before you proceed further, it is best to reform your first error.

CHAP. XXIV

How to take the plot of a Field at two stations taken in any parts thereof, by measuring from either of the stations to the visible angles, by the Plain Table.



His manner of work is chiefly to be used in such fields which are so irregular that from any one part thereof you cannot discern all the angles, or else in such whose largeness will not permit a sufficient view of all the angles at once. The manner of work will be the very same with that in the 16 Chap. only the Instrument, in this, must be placed in two severall places, whereas, in that, the same thing was effected at once placing of the Instrument.

Suppose then that A B C D E F G H I K L and M, were such an irregular Field as is before spoken of. Having made choice of two places within the same for your two stations, as O and Q, from which you may conveniently see all the angles.

First, place your Table at O, turning it about till the needle hang directly over the Meridian line in the Card, represented in this figure by the line N O S. Then fixing the Table there, you must (1) direct the sights to A, and by the side of the Index draw the line A O, containing 7 Chains 46 links.

(2) direct the sights to B, and draw the line B O, containing 7 Chains 18 Links.

(3) direct the sights to C, and draw the line O C, containing 7 Chains 21 links.

(4) direct the sights to D, and draw the line O D, containing 6 Chains 33 Links.

(5) direct the sights to E, and draw the line O E, containing 5 Chains 57 Links.

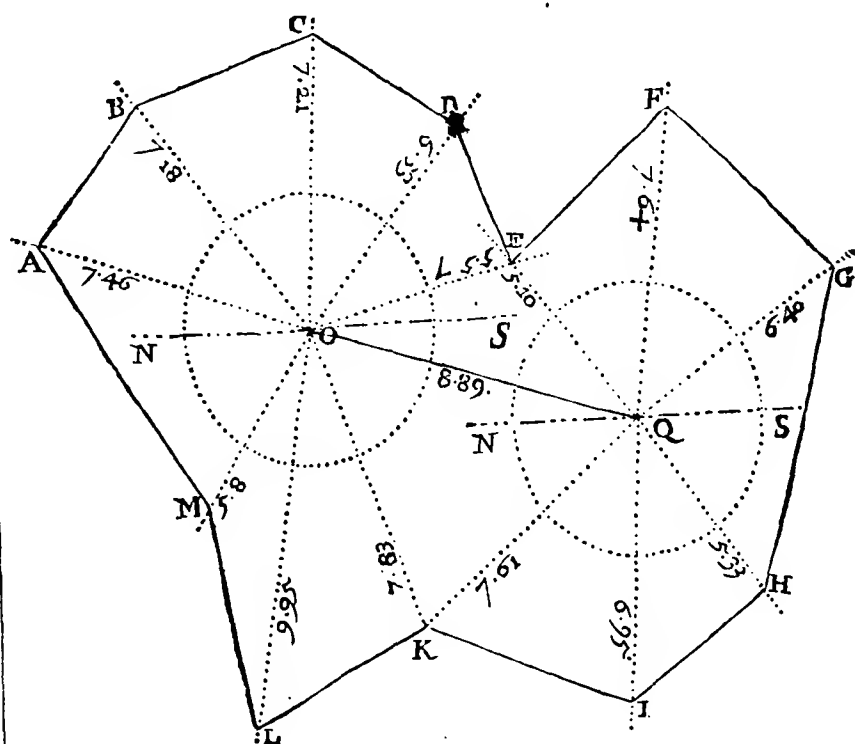
(6) direct the sights to K, and draw the line O K, containing 7 Chains 83 Links.

(7) direct the sights to L, and draw the line O L, containing 9 Chains 95 Links.

(8) direct the sights to M, and draw the line O M, containing 5 Chains 8 Links.

Having thus made observation of these angles which are all that can conveniently be seen from your first station at O, and draw the severall lines O A, O B, O C, O D, O E, O F, O K, O L, and O M, and upon them set the severall lengths as you found them by measuring, as from O to A, 7 Chains 46 Links, from O to B, 7 Chains 18 Links &c. You must then lay the Index again to the point O, and direct the sights to your second station at Q, drawing the line O Q, then measure the distance from O to Q, which let contain 8 Chains 89 Links.

Then



Then remove your Instrument to Q, and lay the Index upon the line O Q, turning the table about till through the sights you direct your first station at O then will the Needle hang directly over the Meridian line in the Card as before, and your Instrument is truly situated in the same position as before, so that you may now deal with the angles F, G, H, and I, (which before you could not conveniently see) as you did with those on the other side of the field, by laying the Index to the point Q, and directing the sights,

- (1) to E, and drawing the line Q E, containing 5 Chains 10 Links.
- (2) to F and drawing the line Q F, containing 7 Chains 64 Links.
- (3) to G and drawing the line Q G, containing 6 Chains 40 Links.
- (4) to H, and drawing the line Q H, containing 5 Chains 33 Links.
- (5) to I, and drawing the line Q I, containing 6 Chains 95 Links.
- (6) to K, and drawing the line Q K, containing 7 Chains 61 Links.

These angles being observed and the lines measured as the former were, you shall finde the severall points E, F, G, H, I, and K, on this side of the Field also, so that you may draw the lines A B, B C, C D, D E, E F, F G, G H, H I, I K, K L, L M, and M A, which shall represent upon your Table the exact figure of the field to be measured.

And here note, that in this Example I make observation of the angles E and K at both stations, but there was no need thereof, only this satisfaction will accrue thereby, for when you have measured your stationarie distance O Q and removed your Instrument to Q, and there fixed it, when you direct the sights to E or K, and measure the distance Q F Q K, and set it off from Q, you shall finde the points E and K to fall directly upon the same points E and K formerly drawn, if there be no error in your work.

And in this manner may you make three, four or five stations for one field if need so require, remembering alwayes, that at every station the Needle hang directly over the Meridian line, or the same degree of the Card at every station.

CHAP. XXV.

How to take the true Plot of a Field at two stations taken in any parts thereof, from whence the angles may be seen by the Theodolite.



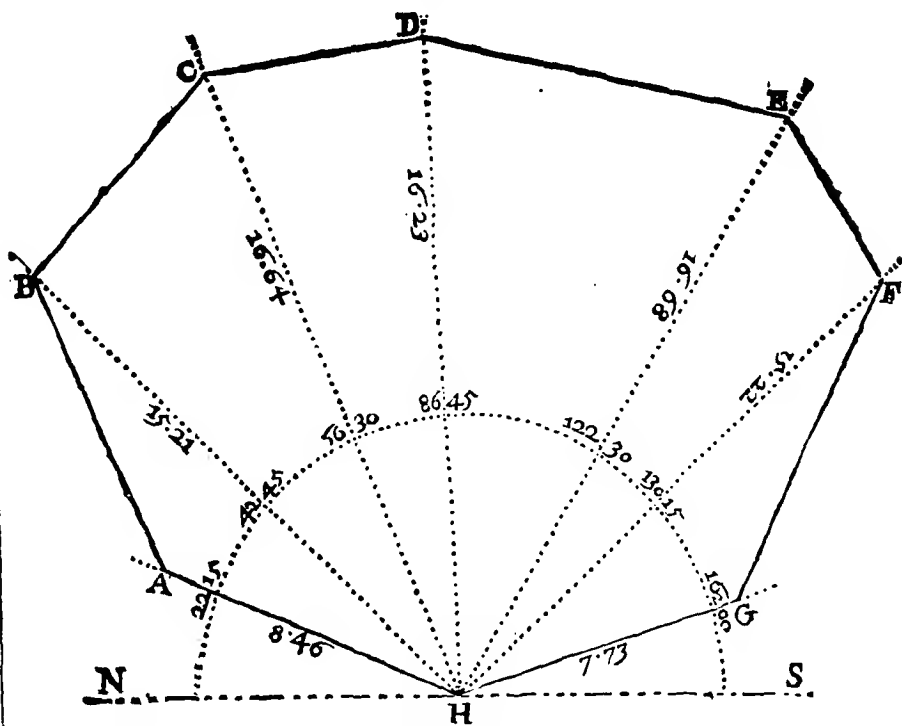
Our stations O and Q being chosen, place your Instrument in the field at O, and turn it about till the Needle hang over the Meridian line, and there fixing it, direct the sights to A, the Index cutting 19 degrees 10 minutes, and the line O A containing 7 Chains 46 Links, the 19 degrees 10 minutes must be placed in the first and second columns of your field-book, and the 7 Chains 46 Links in the third and fourth columns thereof.

Then direct the sights to B, the Index cutting 53 degrees 30 minutes, and the line O B containing 7 Chains 18 Links, which note down in your field-book as before.

In this manner proceed with the rest of the lines and angles namely, so many as you intend to observe at your first station viz. A, B, C, D, K, L, and M: which done, direct the signes to your second station at Q, the Index cutting 18 degrees 15 minutes, which note down in your field-book by it selfe: Also measure the stationarie distance O Q, 8 Chains 89 Links, as before, this also must be noted in your field-book.

Having thus finished one part of the field, remove your Instrument to Q, and laying the Index upon 18 degrees 15 minutes, (which is the inclination or difference of Meridians between your two stations) turn it about till through the signes you espie your first station at O, then will the Needle hang over the Meridian line, and the Instrument will be truly scituate.

Then direct the sights to E, the Index cutting 52 degrees 15 minutes, and the line Q E containing 5 Chains 10 Links, which must be



be noted in your Field-book in all respects as formerly. In this manner make observation of all the other lines angles, as E F G H I and K, which being collected into your Field-book will stand as followeth.

	deg.	Min.	Chai.	Link.
A	19	10	7	46
B	53	30	7	18
C	95	15	7	21
D	132	00	6	33
E	166	30	5	57
K	251	30	7	83
L	282	00	9	95
M	304	30	8	05

The first station
at O.

The stationary distance O Q is 8 Chains 89 Links, and the angle O Q N 18 degrees 15 minutes, the inclination or difference of Meridians.

E	52	15	5	10
F	99	50	7	64
G	148	30	6	40
H	232	30	5	33
I	275	00	6	95
K	321	30	7	61

The second station
at Q.

CHAP. XXVI.

How to take the Plot of a field at two stations taken in any parts thereof, by the Circumferentor.



The use of this Instrument in taking the plot of a field by observing the lines and angles in the midst thereof, is sufficiently shewn already in *Chap. 18.* & the work of this Chapter differeth nothing therefrom, only in this you make observation in two places. Therefore placing the Instrument at O, and directing the sights to A B C D E K L and M, you shall finde the degrees cut by the Needle to be the same with those collected in your field-book at your first station at O. Also, your Instrument being removed to Q, and observation made of the severall angles there, namely, of the angles E F G H I and K, they will likewise be found the same with those observed by the Theodolite at your second station in the last Chapter, and therefore to make repetition thereof again in this place, were superfluous.

Here note, that the Plain Table and Theodolite are the most convenient Instruments for these kinde of practises hitherto treated of, and not the Circumferentor, I only have hinted the use thereof, that the agreement of the severall Instruments might be taken notice of, the Circumferentor serving chiefly for large Champion plains and Wood-lands as will appear hereafter.

CHAP. XXVII.

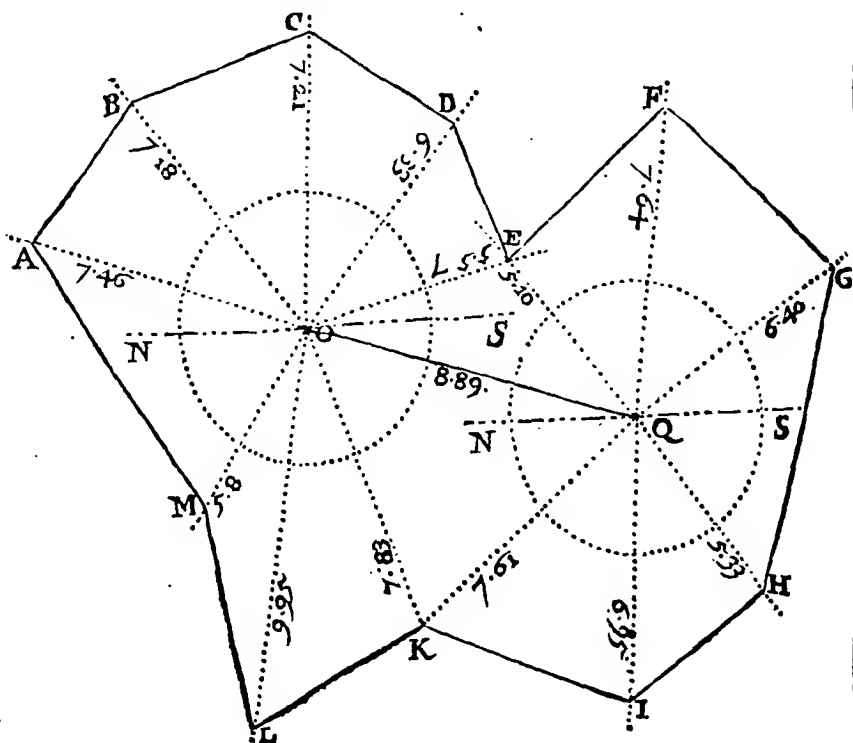
How to protract any observations taken according to the directions of the two last Chapters.



Draw upon your paper the Meridian line M O S, the point O representing your first station: upon this point O place the center of your Protractor, laying the line E F thereof, directly upon the Meridian line N S Then taking your field-book before you observe the degrees there noted, namely,

- (1) at A, 19 degrees 10 minutes the line O A containing 7 Chains 46 Links.
- (2) at B, 53 degrees 30 minutes, the line O B containing 7 Chains 18 Links.
- (3) at C, 95 degrees 15 minutes, the line O C containing 7 Chains 21 Links.

And



And so of the rest, against which degrees and minutes make marks by the edge of your Protractor, and draw lines from O through those marks, as O A, O B, O C, O D, O E, O K, O L, O M, and upon those lines set off the length from O, as you find them collected in your field-book.

Having thus protracted the observations of your first station (before you move your Protractor) make a mark against 18 degrees 15 minutes which is the inclination or difference of Meridians, and draw the line O Q, setting of 8 Chains 89 Links the length thereof from O to Q. Then upon the point Q, place the center of the Protractor, as before, moving it up and down till the line O Q lies just under 18 degrees 15 minutes, and holding it there, lay your field-book before you, and prick down by the side thereof the severall degrees and minutes as by your Instrument you observed them, together with the lengths of the lines as they were measured, drawing lines through those points also as the lines Q E, Q F, Q G, Q H, Q I, and Q K.

Lastly, draw the lines A B, B C, C D, D E, E F, &c. so shall you have upon your paper the exact plot of your field, in which (if there be no error in your work) the line M A being drawn will close exactly with the line B A in the point A.

CHAP. XXVIII.

How to take the Plot of a field at two stations taken in the middle thereof, from either of which all the angles in the field may be seen, with the measuring of one line only, by the Plain Table.

Necessity may some times require the plotting of a field according to the directions which I shal deliver in this Chapter, yet I would have as little use made thereof as possible can be, in regard of the accuteness of the angles, which is more liable to error then any of the wayes formerly taught, although it be grounded upon as firm a Geometrical principle, as any of them.

Let A B C D E F G H be the figure of a field, and let the two stations taken within the same be O and Q.

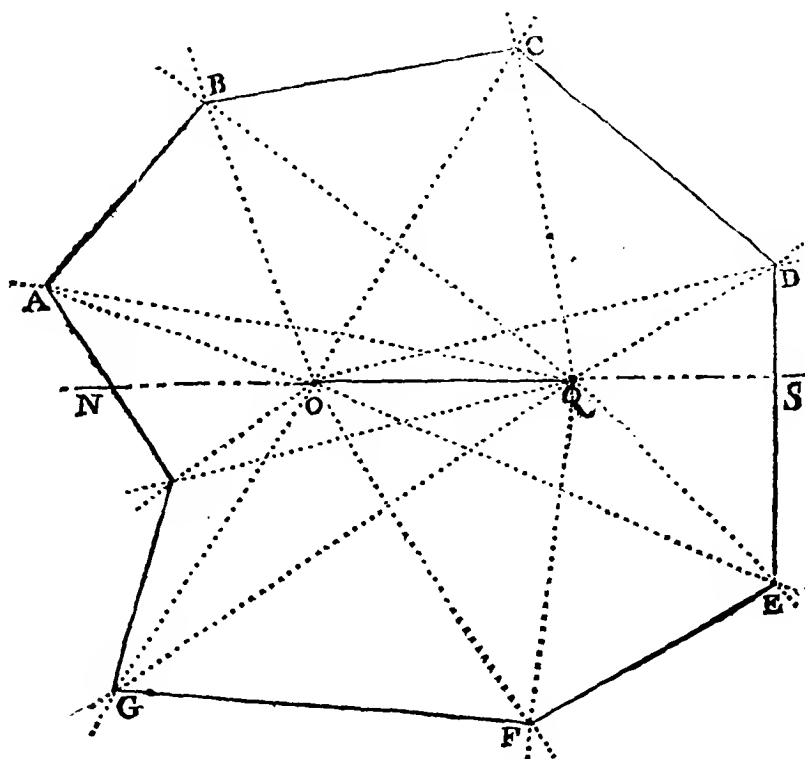
Having placed your Instrument at O, your first station, the Needle hanging directly over the Meridian line of the Card, you must,

- (1) direct the sights to A, and draw the line O A.
- (2) direct the sights to B, and draw the line O B.
- (3) direct the sights to C, and draw the line O C.
- (4) direct the sights to D, and draw the line O D.
- (5) direct the sights to E, and draw the line O E.
- (6) direct the sights to F, and draw the line O F.
- (7) direct the sights to G, and draw the line O G.
- (8) direct the sights to H, and draw the line O C.

This done, direct the sights to your second station at Q, and draw the line O Q upon your Table: then (with your Chain) measure out your stationarie distance O Q, which is 7 Chains, and removing your Instrument to Q (the needle hanging over the Meridian line of the Card as before) make observation as you did at O; As,

- (1) direct the sights to A, and draw the line Q A.
- (2) direct the sights to B, and draw the line Q B.
- (3) direct the sights to C, and draw the line Q C.
- (4) direct the sights to D, and draw the line Q D.
- (5) direct the sights to E, and draw the line Q E.
- (6) direct the sights to F, and draw the line Q F.
- (7) direct the sights to G, and draw the line Q G.
- (8) direct the sights to H, and draw the line Q H.

Now



Now you may plainly perceive by the figure where the correspondent lines at each station intersect or cross each other ; as,

- (1) the lines O A and Q A intersect each other at A.
- (2) the lines O B and Q B, intersect each other at B.
- (3) the lines O C and Q C, intersect each other at C.
- (4) the lines O D and Q D, intersect each other at D.
- (5) the lines O E and Q E, intersect each other at E.
- (6) the lines O F and Q F, intersect each other at F.
- (7) the lines O G and Q G, intersect each other at G.
- (8) the lines O H and Q H, intersect each other at H.

Therefore, if from one to another of these points successively you draw lines, you shall have upon your paper the exact symmetry or proportion of your field, as namely, the lines A B, B C, C D, D E, &c.

In this kind of plotting you cannot but perceive a wonderfull quick dispatch, you being to measure nothing but the distance between your stations, but by reason of the acutenesse of the angles (without exact and curious drawing of your lines, and observing the precise points of intersection) you may run into grosse absurdities and mistakes.

CHAP. XXIX

How to take the Plot of a field at two stations taken in any part thereof, from either of which all the angles in the field may be seen and measuring only the stationarie distance, by the Theodolite or Circumferentor.



You may perceive by what hath been said in the foregoing Chapters, that the manner of work is the same both with the Theodolite & circumferentor, and therefore in this place I make but one example for both Instruments.

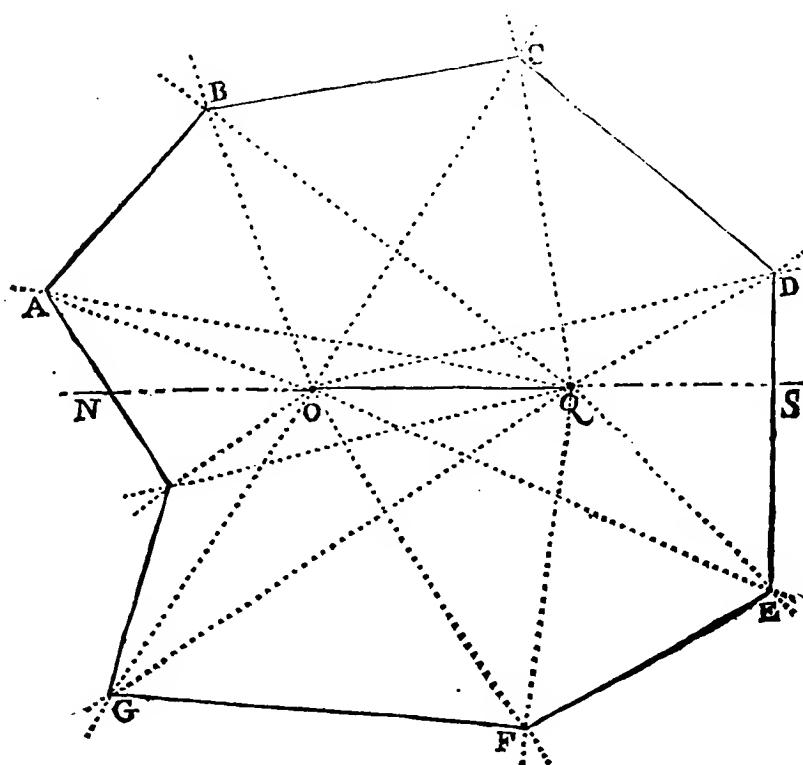
Now to take the plot of the field A B C D E F G and H, by either of these Instruments, place your instrument at O your first station, and turn it about till the needle hang over the Meridian line N S, and fixing it there,

- (1) direct the sights to A, the Index or Needle cutting 21 degrees 30 minutes.
- (2) direct the sights to B, the Index or Needle cutting 69 degrees 15 minutes.
- (3) direct the sights to C, the Index or needle cutting 124 degrees 45 minutes.
- (4) direct the sights to D, the Index or Needle cutting 168 degrees 10 minutes.
- (5) direct the sights to E, the Index or Needle cutting 202 degrees 30 minutes.
- (6) direct the sights to F, the Index or Needle cutting 237 degrees 30 minutes.
- (7) direct the sights to G, the Index or Needle cutting 307 degrees 00 minutes.
- (8) direct the sights to H, the Index or Needle cutting 328 degrees 30 minutes.

This done, measure your stationarie distance O Q, which suppose to contain 7 Chains, and remove your Instrument to Q, turning it about till the Needle hang directly over the Meridian line as before, and there fix it; then,

- (1) direct the sights to A, the Index or Needle cutting 21 degrees 00 minutes.
- (2) direct the sights to B, the Index or Needle cutting 35 degrees 30 minutes.
- (8) direct the sights to C, the Index or Needle cutting 79 degrees 45 minutes.

(4) di-



- (4) direct the sights to D, the Index or Needle cutting 153 degrees 15 minutes.
- (5) direct the sights to E, the Index or Needle cutting 224 degrees 50 minutes.
- (6) direct the sights to F, the Index or Needle cutting 279 degrees 30 minutes.
- (7) direct the sights to G, the Index or Needle cutting 329 degrees 00 minutes.
- (8) direct the sights to H, the Index or Needle cutting 347 degrees 30 minutes.

Having thus made observation of all the angles round about the field at both stations and noted the degrees cut by the Index of the Theodolite or the Needle of the Circumferentor, and noted them down in your field-book, together with the distance between your two stations, you may proceed to protract your work as is taught in the next Chapter.

CHAP. XXX.

How to protect any observations taken according to the directions of the last Chapter.

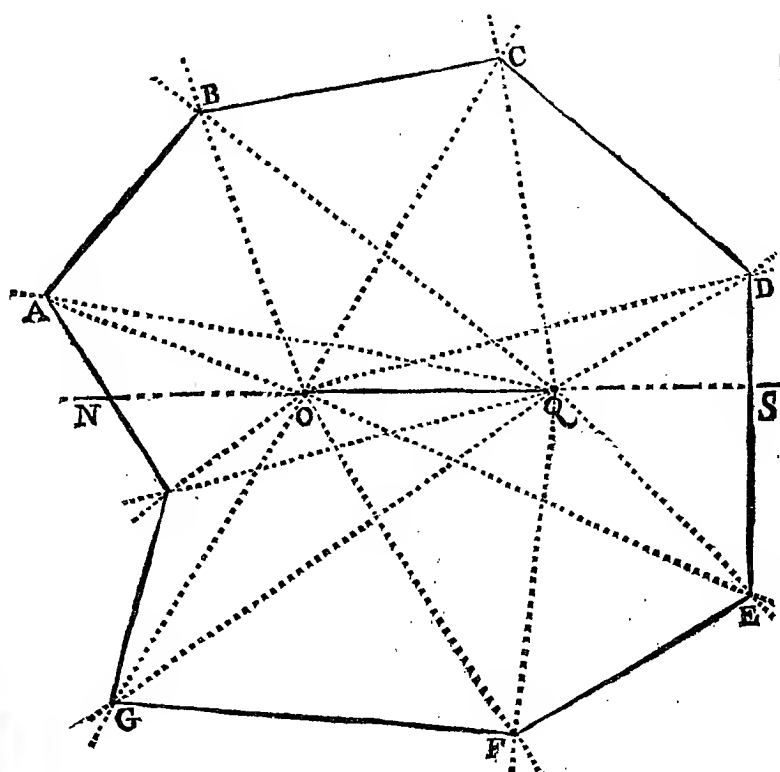
First draw the Meridian line N S, upon which line assigne any point at pleasure, as O for your first station, unto which point apply the center of your Protractor with the line E F thereof upon the Meridian line N S. Then looke into the Field-book for the degrees observed at your first station at O, and make marks against those degrees by the edge of your Protractor, and when you have marked them all, draw links from O through every of them, as the lines O A, O B, O C, &c.

Then from your Scale take 7 Chains (which is your stationary distance) and place it from O to Q, which represents your second station, upon this point Q, place the center of your Protractor and lying your Field-book before you prick down the degrees by the edge of the Protractor, as you finde them noted in your Field-book at your second station at Q, and through those points draw the lines Q A, Q B, Q C, &c.

The line Q A crossing the line O A in the point A.
 The line Q B crossing the line O B in the point B.
 The line Q C crossing the line O C in the point C.
 The line Q D crossing the line O D in the point D.
 The line Q E crossing the line O E in the point E.
 The line Q F crossing the line O F in the point F.
 The line Q G crossing the line O G in the point G.
 The line Q H crossing the line O H in the point H.

Therefore if you draw the lines A B, B C, C D, D E, E F, F G, G H, and H A, it shall be the exact plot or figure of the field required.

¶ I might now proceed to shew the manner of taking the plot of any field without approaching nigh the same; but in regard the performance thereof differeth nothing at all from that which is already taught in the 13, 14, and 15, Chapters of the fourth Book, I shall therefore in this place passe it over as superfluous.



CHAP. XXXI.

How to take the Plot of a Wood, Park, or other large Champion plain by the Plain Table, by measuring round about the same, and making observation at every angle,

Hitherto we have shewed how the plot of any plain and even ground, or any small enclosure may be taken severall wayes, as being the easiest for a practioner to try experience upon, I now come to shew how the I plot of any large Champion plain, or over-grown wood may be measured, for in such kinde of grounds the former directions will be of little validity, for the largeness of the Plain, or the thickness of the wood may many times hinder both your sights and measuring; therefore the best way to measure these kinde of Lands is to go about them, and make observation at every angle.

Suppose the following figure A B C D E F G to be a large Wood or other Champion plain, whose Plot you desire to take upon your Plain Table.

1 Place your Instrument at the Angle A, directing your sights to the next angle at B, and by the side thereof draw a line upon your Table, as the line A B, then measure by the hedge side from the angle A, to the angle B, which suppose 12 Chains 5 links, then from your Scale take 12 Chains 5 Links, and set that distance upon your Table from A to F.

2 Remove your Instrument from A, and set up a mark where it last stood, and place your Instrument at the second angle at B; then laying the Index upon the line A B, turn the whole Instrument about till through the back-sights you see the mark which you set up at A, and there screw the Instrument: then laying the Index upon the point B, direct your sights to the third angle at C, and draw the line B C upon your Table, Then measuring the distance B C 4 Chains 45 Links, take that distance from your Scale and set it upon your Table from B to C.

3 Remove your Instrument from B, and set up a mark in the room thereof, and place your Instrument at C, laying the Index upon the line C B, and turn the whole Instrument about till through the back-sights you espie your mark set up at B, and there fasten the Instrument: then laying the Index on the point C, direct the sights to D, and draw upon your Table the line C D then measure from C to D 8 Chains 85 Links, and set that distance upon your Table from C to D.

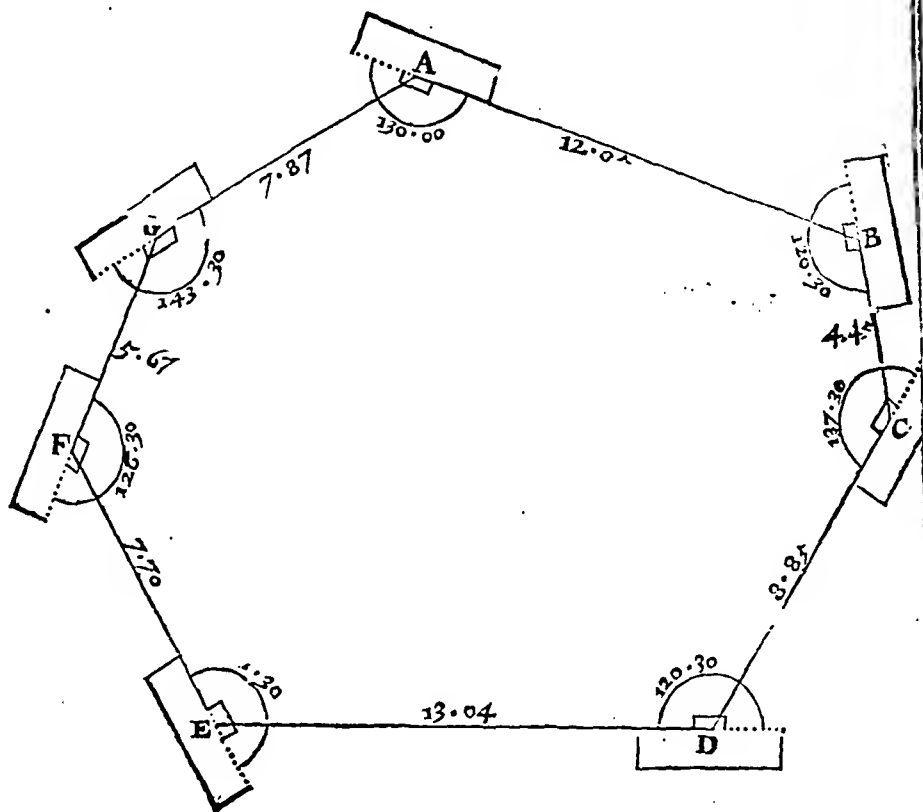
4 Remove your Instrument to D (placing a mark at C where it last stood) and lay the Index upon the line D C, turning the whole Instrument about till through the back-sights you espie the mark at C, and there fasten the Instrument: then lay the Index on the Point D, and direct the sights to E and draw the line D E then with your Chain measure the distance D E 13 Chains 4 Links, and set that distance upon your Table from the point D unto E.

5 Remove your Instrument to E (placing a mark at D where it last stood) and laying the Index upon the line D E turn the whole Instrument about till through the back-sights you see your mark at D, and there fasten the Instrument: then lay the Index on the point E, and direct the sights to F, and draw the line E F, then measure the distance E F 7 Chains 70 Links, which take from your Scale, and set it on your Table from E to F.

6 Remove your Instrument to F (placing a mark at E where it last stood) and lay the Index upon the line E F, turning the Instrument about, till through the back-sights you see your mark set up at E, and there fasten the Instrument: then laying the Index on the point F, direct the sights to G, and draw the line F G upon your Table, then measure the distance F G 5 Chains 67 Links, and set that off upon your Table from F to G.

7 Remove your Instrument to G (setting up a mark at F where it last stood) and lay the Index upon the line F G turning the whole

Instru



Instrument about, till through the sights you see the mark at F, and there fasten the Instrument, then laying the Index upon the point G direct the sights to A (your first mark) and draw the line G A, which shall passe directly through the point A, where you first began, if you have truly wrought.

In this manner may you take the plot of any Champion plain be it never so large, and here note, that many times hedges are of such a thicknesse that you cannot come neere the sides or angles of the field, either to place your Instrument or measure your lines; therefore, in such cases, you must place your Instrument, and measure your lines parallel to the side thereof, and then your work will be the same as if you measured the hedge it selfe.

Note also, that in thus going about a field, you may much help your selfe by the Needle, for looke what degree of the Card the needle cuts at one station, if you remove your Instrument to the next station, and with your back-sights look to the mark where your Instrument last stood, you shall finde the Needle to cut the same degree again, which will give you no small satisfaction in the prosecution of your work.

Of shifting of Paper.

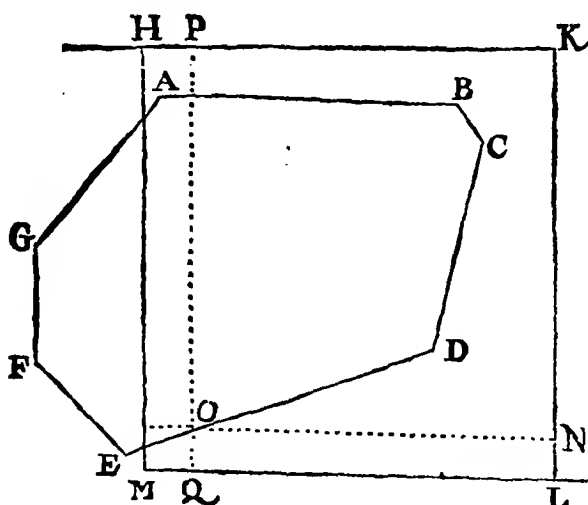
¶ In the taking of the plot of a field by the Plain Table and going about the same, as is taught in this Chapter, it may so fall out, (if the field be very large, or that you are to take many inclosures together) that the sheet of paper upon your Table will not hold all your work, but you must be forced to take off that sheet which is upon the Table, and put another clean sheet in the room thereof: and (in the plotting of a Mannor or Lordship) many sheets may be thus changed, which we call, shifting of paper, the manner of performing whereof, it is as followeth.

Example.

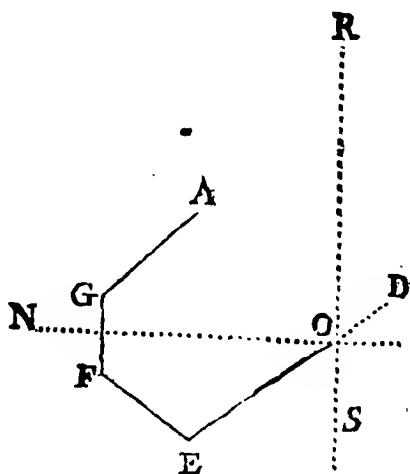
Suppose that in going about to take the plot of the field A B C D E F G, as in this Chapter is taught, that when you have made choice of the angle at A, for the place of beginning, and proceeded from thence to B, and from B to C, and from C to D, that when you come to the angle at D, and are to draw the line D E you want room to draw the same upon the Table, you must then do as followeth.

First, through the point D, draw the line D O, which is almost so much of the line D E as the Table will contain, then near the edge of the Table H M, draw a line parallel to H M, as P Q, and another line at right angles thereunto through the point O, as O N, the point O being the farthest point that you can bring upon your Table.

This being done, marke this sheet of paper with the figure (1) about the middle thereof, for your first sheet, then taking this sheet off of your Table, put another clean sheet upon the Table, and draw thereupon a line parallel to the contrary edge of the Table, as the line R S in the other figure, then taking your first sheet of Paper, lay it upon the Table so that the line P Q may exactly lie upon the line R S to best advantage, as at the point O in the second figure, then with your Compass point draw so much of the line O D upon the clean sheet of Paper as the Table will bear.



Having thus done proceed with your work upon your new sheet beginning at the point O, and so going forward with your work in all respects, as before is taught in the beginning of this Chapter, as from O to E, from E to F, from F to G, and and from G to A, (by this direction) shifting your paper as often as you shall have occasion.



CHAP. XXXII.

How to take the Plot of a Wood, Park, or other large Champion plain, by going about the same, and making observation at every angle thereof, by the Theodolite.

Place your Instrument at the angle A, and lay the Index on the diameter thereof, turning the whole Instrument about till through the sights you espie the second angle at B, then fastening it there, turn the Index about till through the sights you see the angle at G, the Index cutting 130 degrees 00 minutes, which is the quantity of the angle G A B, and the line A B containing, 12 Chains 5 Links which you must note down in your field-book as formerly.

2 Remove your Instrument to B, laying the Index on the diameter, and turn it about till through the sights you see the third angle at C, and there fasten it, then turn the Index backward till through the sights you see the angle at A, the degrees cut by the Index being 120 degrees 30 minutes, the quantity of the angle A B C, and the line B C containing 4 Chains 45 Links, which you must note in your Book as before.

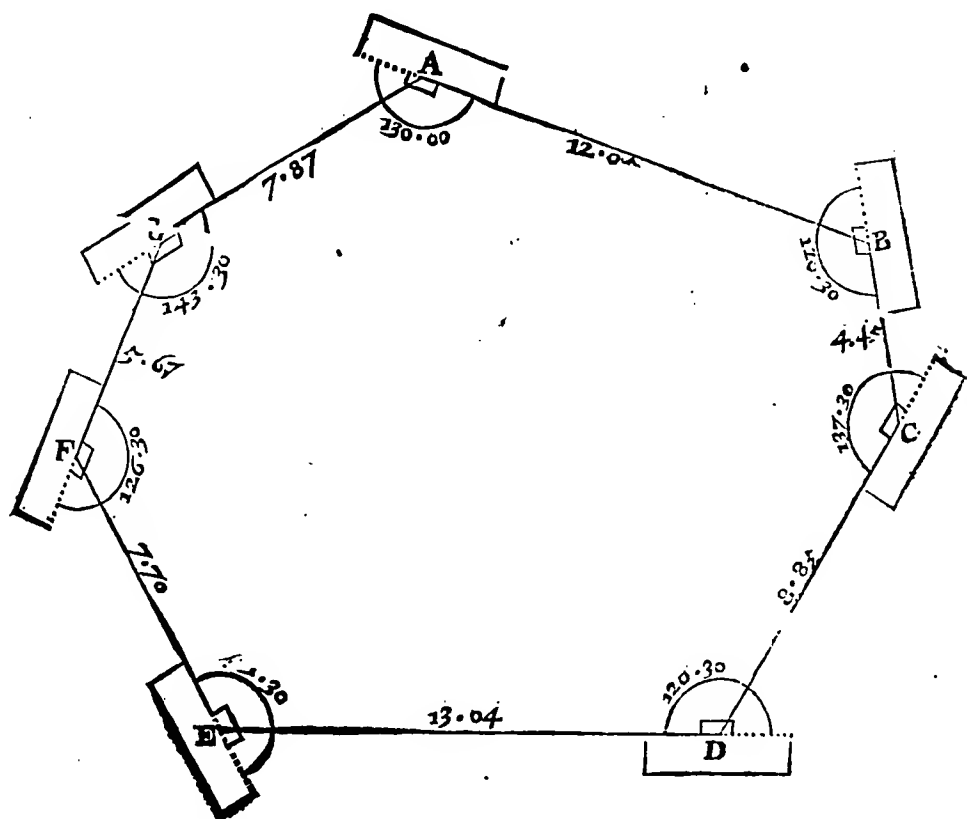
3 Remove your Instrument to C, and lay the Index on the diameter thereof, turning the Instrument about till through the sights you see the fourth angle at D, and there fixing it, direct the sights back again to B, the Index cutting 137 degrees 30 minutes, and the line C D being 8 Chains 85 Links.

4 Place your Instrument at D, and lay the Index on the Diameter, turning the Instrument about, till through the sights you espie the fifth angle at E, and there fixing in, turn the Index backward towards C, the degrees cut thereby being 120 degrees 30 minutes, and the line D E 13 Chains 4 Links, which must be noted in your field-book.

5 Remove your Instrument to E, and lay the Index on the Diameter thereof, turning the Instrument about till through the sights you see the angle at F, and there fixing it, turn the Index backward to D, the degrees cut being 121 degrees 30 minutes, and the line E F 7 Chains 70 Links, which note down also.

6 Place your Instrument at F, and lay the Index on the Diameter thereof, turning the Instrument about till through the sights you see the angle at G, and there fixing it, turn the Index till through the sights you espie the former angle at E, the degrees cut being 126 degrees 30 minutes, and the length of the line F G being 5 Chains 67 Links.

7 Lastly,



7 Lastly, Place the Instrument at G, and lay the Index on the Diameter, turning the whole Instrument about till through the sights you espie the angle at A, and there fixing it, direct the sights back again to F, the degrees cut by the Index being 143 degrees 30 minutes, and the length of the line G A 7 Chains 87 Links

Having thus made observation at every angle of the field in this manner, and collected the quantity of every angle, and the length of every line in your field-book, you shall finde them to stand as followeth.

	Degrees	Minutes	Chains	Links
A	130	00	12	5
B	120	30	4	45
C	137	30	8	85
D	120	30	13	4
E	121	30	7	70
F	126	30	5	67
G	143	30	7	87

CHAP. XXXIII.

How to protract or lay down any observations taken according to the doctrine of the last Chapter.

Consider which way your Plot will extend, and accordingly upon the paper that you would have the Plot of your field described, draw a line at pleasure, as the line GA. Then place the center of your Protractor upon the point A, and (because the angle at your first observation at A, was 130 degrees 00 minutes) turn it about till the line AG lie directly under 130 degrees, and then at the beginning of the Protractor (which is at 00 degrees, noted (in the figure thereof pag. 51.) with the letter E,) make a mark, and through it draw the line AB, setting 12 Chains 5 Links (the length of the same line) from A to B.

2 Lay the center of your Protractor upon the point B, and seeing the degrees cut at B were 120 degrees 30 minutes, therefore turn the Protractor about till the line AB lies directly under 120 degrees 30 minutes, and then at the beginning of the degrees make a mark, and through it draw the line BC, the length thereof being 4 Chains 45 Links.

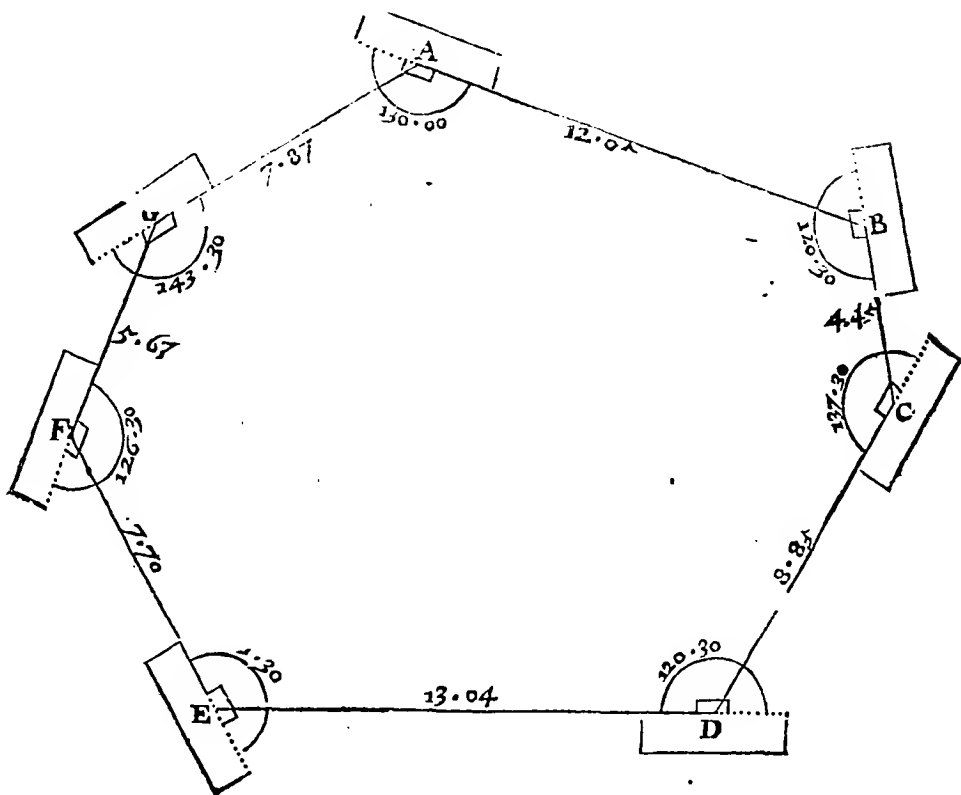
3 Lay the center of the Protractor on the point C, turning it about till the line BC lies directly under 137 degrees 30 minutes (which were the degrees cut at your observation at C,) and then making a mark at the beginning or 00 degrees of your Protractor, through it draw the line CD, setting 8 Chains 85 Links thereon from C to D.

4 Bring the center of your Protractor to the point D, turning it about till the line CD lies directly under 120 degrees 30 minutes, and then making a mark at the beginning of the Protractor, through it draw the line DE, and upon it set 13 Chains 4 Links from D to E.

In this manner must you deale with all the rest of the angles, and when you come to protract the angle at F, which is the last angle, and have drawn the line FG, you shall finde it to cut the line AG first drawn in the point G, leaving the line AG to contain 7 Chains 85 Links, and the line FG 5 Chains 67 Links; and in this, practise is better then many words, and the sight of the figure better then a whole Chapter of information, in which figure, you may see the Protractor lie at every angle in its true position.

This work may be performed other wise by protracting your last observation first so having drawn the line AG, lay the center of the Protractor on G, and the Meridian line thereof (namely EF) on the line GA, then (because the degrees cut at your observation at G, were 143 degrees 30 minutes) make a mark with your protracting pin against 143 degrees 30 minutes and through it draw the line GF, upon which line from G to F, set 5 Chains 67 Links.

Then



Then placing the center of your Protractor on the point F, and the Meridian line thereof upon the line FG, making a mark by the edge of the Protractor against 126 degrees 30 minutes (which were the degrees cut by the Index at your observation at F, and through that point draw the line FE, setting 7 Chains 70 Links thereupon from F to E.

And in this manner must you proceed with the rest of the lines and angles, and at last you shall finde the plot of your field to close at A, as before it did at G, and if the sides and angles were never so many, the manner of the work would be the same.

Here note that if in going about a field, and measuring the angles thereof with the Theodolite or degrees on the frame of the Table (as in Chap. 32.) that if you meet with any angle that bendeth inwards in the field, you must reckon that angle to be so much above 180 degrees as the bending is, and when you note the degrees of such an angle in your field-book, you may make this \succ or the like mark against them for a remembrance when you come to protract, and in protracting you must turn the Semicircle of the Protractor the contrary way to what you do in protracting of other angles.

CHAP. XXXIV.

How to know whether you have taken the angles of a Field truly, as in Chap. 33.



Having made observation of all the angles in the field with your Instrument, and noted them down in your field-book as is done in the later end of *Chap. 32.* collect the quantity of all the angles found at your severall observations into one sum, and multiply 180 degrees by a number lesse by two then the number of angles in the field, and if the product of this multiplication be equall to the totall summe of your angles, then is your work true, other wise not.

EXAMPLE.

deg.	min.	In the work of the 32 <i>Chap.</i> the angles found were as in the margine, the summe of them being 500 degrees 00 minutes. Now, because the field consisted of 7 angles, you must therefore multiply 180 degrees by 5, (which is a number lesse by two then the number of angles in the field) and the product will be 900, which exactly agreeing with the summe of all the angles in the field as you found them by observation, you may conclude that your work is exactly performed.
130	00	
120	30	
137	30	
120	30	
121	30	
126	30	
143	30	
500	00	

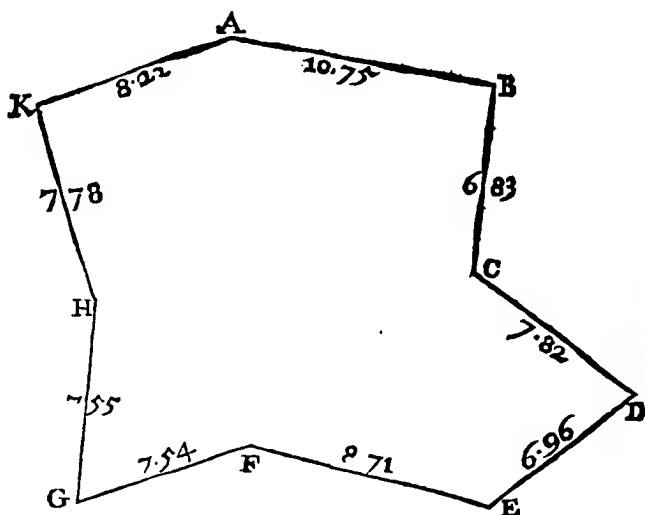
This rule is general when all the angles of the field be inward angles, but if any of them be outward angles, then you are to take the complements of such angles to 180 degrees, which number of degrees is to be added to the rest of the angles, and their aggregate shall be equal to the product of the multiplication of 180, by a number less by two then the angles of the field, but these outward angles (be there never so many in one field) must not be accounted as angles, but wholly rejected.

CHAP. XXXV.

How to take the Plot of any Wood, Park, or other large Champion plain, by going about the same, and making observation at every angle thereof, by the Circumferentor.



Have before shewn the use of the Circumferentor in taking the plot of any small inclosure several wayes, but for those kind of practises the Circumferentor is no convenient Instrument, the use thereof in those works was only intimated, that the agreement of the several Instruments in the performance of the same thing, might the better appear. Now the



the Circumferentor is a most absolute Instrument for the surveying of any large and spacious business, as a Park, Wood, or other large Common field or Champion plain, the use thereof differing from all that hath hitherto been delivered.

Suppose then that A B C D E F G H K were a large field or other inclosure to be plotted by the Circumferentor.

1 Placing your Instrument at A (the Flower-de-luce towards you) direct the sights to B, the South end of the Needle cutting 191 degrees, and the ditch, wall or hedge A B containing 10 Chains 75 Links, the degrees cut, and the line measured, must be noted down in your field-book as in the foregoing examples.

2 Place your Instrument at B, and direct the sights to C, the South end of the Needle cutting 279 degrees and the line B C containing 6 Chains 83 Links, which note down in your field-book as before.

3 Place the Instrument at C, and direct the sights to D, the Needle cutting 216 degrees 30 minutes, and the line C D containing 7 Chains 82 Links.

4 Place the Instrument at D, and direct the sights to E, the Needle cutting 327 degrees, and the line D E containing 9 Chains 96 Links.

5 Place the Instrument at E and direct the sights to F, the Needle cutting 12 degrees 30 minutes, and the line E F containing 9 Chains 71 Links.

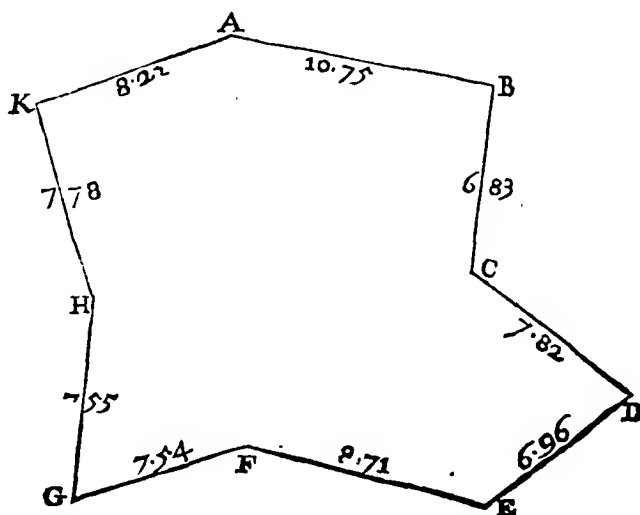
6 Place the Instrument at F, and direct the sights to G, the Needle cutting 342 degrees 30 minutes, and the line F G, containing 7 Chains 54 Links.

7 Place the Instrument at G, and direct the sights to H, the Needle cutting 98 degrees 30 minutes, and the line G H containing 7 Chains 52 Links.

8 Place

8 Place the Instrument at H, and direct the sights to K, the Needle cutting 71 degrees, and the line HK containing 7 Chains 78 Links,

9 Place the Instrument at K, and direct the sights to A (where you began) the Needle cutting 161 degrees 30 minutes, and the line KA containing 8 Chains 22 Links.



Having gon round the field in this manner, and collected the degrees cut, and the lines measured in the severall columns of your field-book according to former directions, you shall finde them to stand as followeth, by which you may protract and draw the plot of your field as in the next Chapter.

	Degrees.	Minutes.	Chains.	Links.
A	191	00	10	75
B	279	00	6	83
C	216	30	7	82
D	325	00	6	96
E	12	30	9	71
F	342	30	7	54
G	98	30	7	54
H	71	00	7	78
K	161	30	8	22

In going about a field in this manner, you may perceive a wonderful quick dispatch, for you are only to take notice of the degrees cut once at every angle, and not to use any back-sight as in the fore going work of the Theodolite: but to use back-sights with the Circumferentor is best for to confirm your work; for when you stand at any angle of a field, and direct your sights to the next, and observe what degrees the South end of the needle cutteth, if you remove your Instrument from this angle to the next, and look to the mark or angle where it last stood, with your back-sights the Needle will there also cut the same degree as before, which ought to be done, and may be, without much losse of time.

So the Instrument being placed at A if you direct the sights to B, you shall finde the Needle to cut 191 degrees, then removing your Instrument to B, if you direct the back-sights to A, the Needle will then also cut 191 degrees.

Now for dispatch and exactnesse (if the Needle be good, the Card well divided, and the degrees, by a good eye) truly estimated) the Circumferentor, for large and spacious grounds is as good as any, and therefore observe well the manner of protracting.

A Compendium.

Q Norwithstanding the quick dispatch this Instrument maketh, there is one Compendium more which I will here insert, whereby (if one be taken) the one half of the work will be saved, for whereas (by the directions in this Chapter) you are to place the Instrument at every angle, it will be sufficient now to place it, but at every second angle, I will instance in the foregoing example.

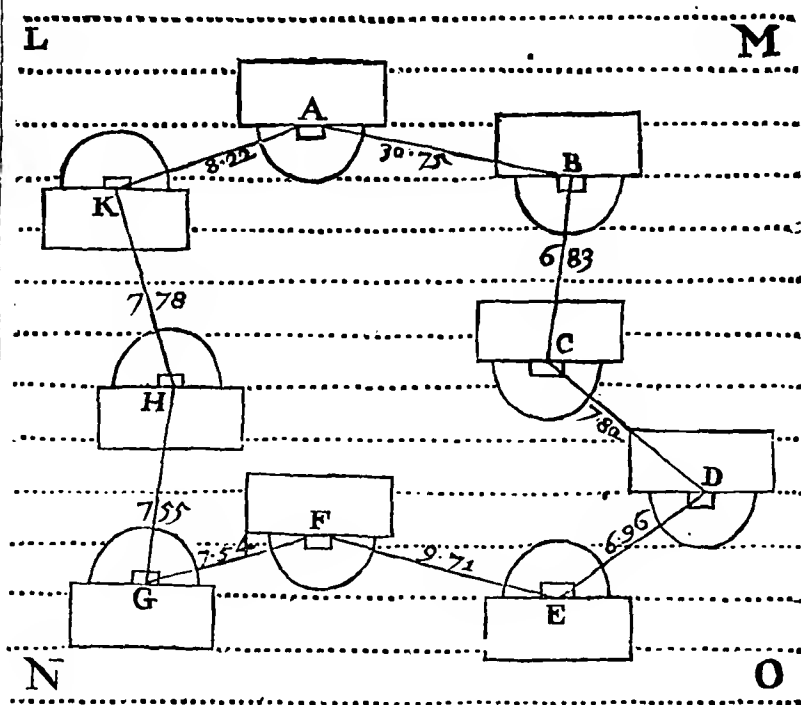
1 Placing your Instrument at A, and directing the sights to B, you find the Needle to cut 191 degrees; Then

2 Placing the Instrument at B, and directing the sights to C, you find the Needle to cut 279 degrees. And

3 Placing the Instrument at C, and directing the sights to D, you find the Needle to cut 216 degrees.

Now, having placed your Instrument at A, and noted down the degrees cut by the Needle, which were 191, you need not go to the angle B at all, but go next to the angle G, and there place your Instrument, and directing your sights backwards to B, you shall find the Needle to cut 279 degrees, which was the same degrees.

degrees as were before cut when the Instrument was placed at B, so that the labour of placing the Instrument is wholly saved. Then (the Instrment still standing at C) direct the sights to D , and the Needle will cut 216 degrees, as before, which note in your field-book. This done remove your Instrument to E, and make observation according to this last direction , and you shall find your work to be the same as before, then remove the Instrument from E to G, and G to K, and so to every second angle, be there never so many, and here you see that half the labour is cleerly saved, and the work the same, as if the Instrument had been placed at either angle.



CHAP. XXXVI.

How to protract any observations taken by the Circumferentor, according to the doctrine of the last Chapter.

According to the largeness of your Plot provide a sheet of paper or skin of parchment, as LMNO, upon which draw the line LM, and parallel thereto, draw divers other lines, quite through the whole paper or parchment, as the pricked lines in the figure drawn between LM and NO, and let the distance of each of these parallels one from another be somewhat lesse then the breadth of the Scale of your Protractor. These parallel lines thus drawn do represent Meridians, and are hereafter so called, upon one or other of these lines (or parallel to one of them) the Meridian line of your Protractor noted in the figure thereof *pag. 51*, with EF) must alwayes be laid when you protract any observations taken by the Circumferentor as in the Chapter before going.

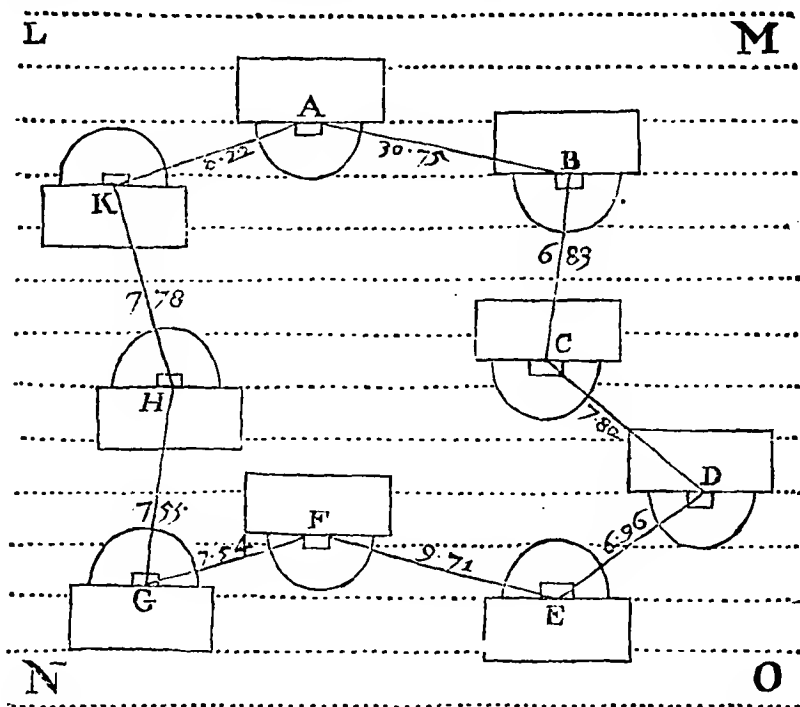
Your paper or parchment being thus prepared, assigne any point upon any of the Meridians, as A, upon which point place the center of your Protractor, laying the Meridian line thereof just upon the Meridian line drawn upon your paper, as you see it lie in the figure annexed. Then looke in your field-book what degrees the needle cut at A which were 191 degrees, now, because the degrees were more then 180, you must therefore lay the semicircle of the Protractor downwards and holding it there, with your protracting pin make a mark against 191 degrees, through which point, from A, draw the line A B, which contains 10 Chains 75 Links.

2 Lay the center of the Protractor on the point B, with the meridian line thereof parallel to one of the pricked Meridians drawn upon the paper, and seeing the degrees cut at B were more then 180, viz. 279, therefore the Semicircle must lie downwards, and so holding it, make a mark against 279 degrees, and through it draw the line B C, containing 6 Chains 83 Links.

3 Place the center of the Protractor on the point C, the Meridian line thereof lying parallel to one of the pricked Meridians drawn on the paper, then the degrees cut by the Needle at your third observation at C being above 180, namely 216 degrees 30 minutes, therefore must the Semicircle lie downwards, then making a mark against 216 degrees 30 minutes, through it draw the line C D, containing 17 Chains 82 Links.

4 Lay the center of the Protractor upon the point D, the degrees cut by the Needle at that angle being 325, which, being above 180, lay the Semicircle of the Protractor downwards, and against 325 degrees make a mark with your protracting pin, through which point, and the angle D, draw the line D E, making it to contain 6 Chains 96 links.

5 Remove your Protractor to E, laying the Meridian line thereof upon (or parallel to) one of the Meridians drawn upon your paper, and because the degrees cut by the Needle at this angle were lesse then 180, namely, 12 degrees 30 minutes, therefore, lay the Semicircle of the Protractor upwards, and make a mark against 12 degrees 30 minutes, through which draw the line E F, containing 9 Chains 71 Links.



6 Lay the center of the Protractor upon the point F, and because the degrees to be protracted are above 180, viz, 342 degrees 30 minutes, lay the Semicircle of the Protractor downwards, and make a mark against 342 degrees 30 minutes, drawing the line F G which contains 7 Chains 54 Links.

And in this manner must you protract all the other angles G, H, and K, and more, if the field had consisted of more angles, alwayes observing this for a generall rule, to lay the meridian line of the Protractor upon (or parallel to) one of the Meridians drawn upon your paper (which the small divisions at each end of the Scale of the Protractor will help you to do,) and if the degrees you are to protract be lesse then 180 (as those at G H and K are) to lay the Semicircle of the Protractor upwards, or from you; and if they be above 180 degrees (as those at A B C and D are) to lay the Semicircle downwards, as you see done in the figure.

¶ Notwithstanding the Compendium in the last Chapter, where the Instrument was placed but at every second angle, yet the manner of protracting is the same as in this Chapter without any alteration.

CHAP. XXXVII.

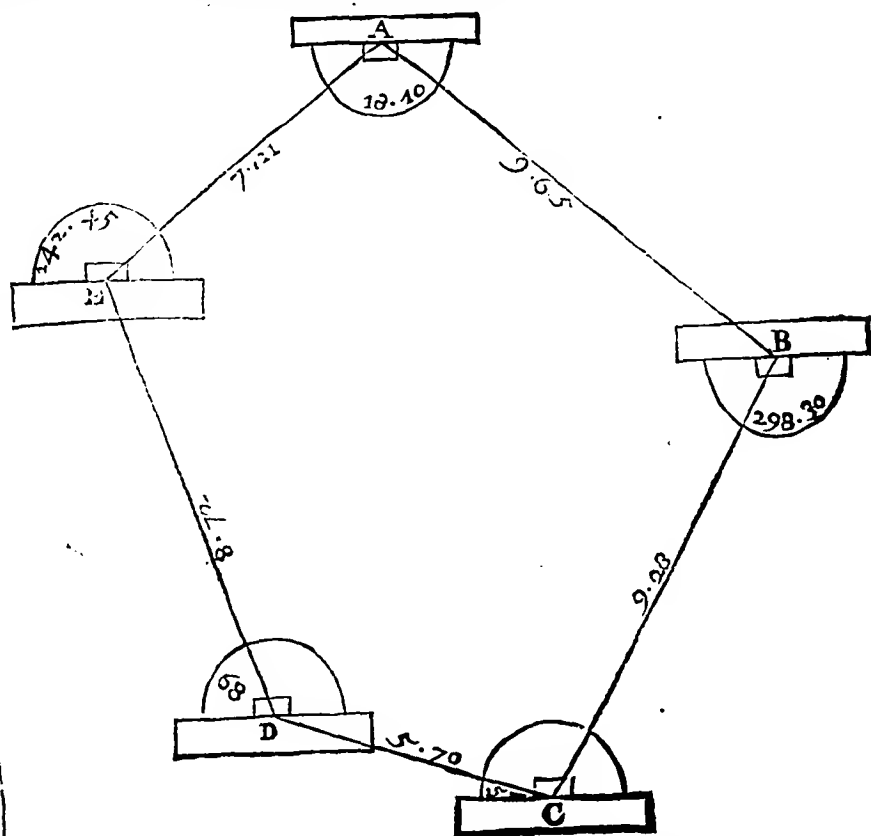
How to take the Plot of any Park, Forrest, Chase, Wood, or other large Champion plain, by the Index and Needle, together with the degrees on the frame of the Table, must commodiously supplying the use of the Peractor.



The use of the Plain Table, Theodolite and Circumferentor, hath been sufficiently taught in the preceding Chapters, and their agreement in all kind of practises fully intimated, so that you may perceive by what hath been hitherto delivered, that for some kind of works one Instrument is better then another, and for large and spacious businesses, the Circumferentor is the best (the Needle being good, no impediment neere to hinder the playing or vertue thereof) there being only this objection to be made against it, *viz.* that the degrees in the Card are (for the most part) so small that they cannot be truly estimated and so may occasion the greater error in protraction For the salving of this grand inconvenience Master *Ruthborn* hath a contrivance in his Book of Surveying by an Instrument which he calleth a Peractor which is no other then a Theodolite, only the Box and Needle is so fitted to the center of the Instrument that when the Instrument is fixed in any position whatsoever, the Index may be turned about, and yet the Box and Needle remain immoveable The benefit of this contrivance is, that whereas in the Circumferentor the degrees are cut by the Needle, here the same degrees are cut by the Index, and therefore are larger, the use whereof is thus.

Place the Peractor at any angle of a field, and turn it about till the Needle hang directly over the Meridian line in the Card then fix the Instrument there, and turn the Index about till through the sights you espie the mark or angle you would looke at, then shall the Index cut the same degrees and minutes upon the Limbe of the Peractor, as the Needle would have cut upon the Card of the Circumferentor, if used as is before taught; yet notwithstanding this contrivance you see you must be beholding to the Needle, the convenience only being, that the degrees which you are to note in your field-book, are larger upon the limb of the Instrument then in the Card, which (I confesse) is something considerable.

Now if any man have a desire to make use of this Instrument, thinking none better, he is much deceived, for the Box and Needle being screwed to the index of the Plain Table, and fastened to the center of the degrees upon the same frame of the Table, performeth the work of the Peractor much better then the Peractor it self; for, whereas in the use of Peractor, you always let the needle hang



hang over the meridian line, and let the Index cut the deg, in this you shall see that in going round a field, the Needle in the Card, and the Index on the frame of the Table will cut like degrees, so that you have a double testimonie for every observation with the same facility, which is no small satisfaction. Now because (I know) there are some which are wedded to the use of this Instrument, and induce all men whom they can perswade to the use thereof, thinking none so good, or at least better, I will here in one example briefly shew the use thereof, as it is to be performed by the degrees projected on the frame of the Plain-Table, and thereby make the Plain Table more generall.

Let A B C D E be a field to be measured by the Index and Needle on the Plain Table, supplying the use of the Peractor.

1 Place your Instrument at A, laying the Index and sights with the Box and Needle screwed thereto upon the Diameter of the Table, then the Index so lying; turn the whole Instrument about till the Needle hang directly over the Meridian line in the Card, then screw the Instrument fast, and turn the Index about upon the center, till through the sights you espie your second angle at B, then you shall see that the South end of the Needle will cut upon the Card

in

in the Box, about 218 degrees, & the Index (at the same time) upon the Table will cut 218 degrees 10 minutes, which must be noted down in your field book as hath been severall times before taught, and measure the distance A B 9 Chains 65 Links, which you must note down in your field-book also.

¶ By this you may see the convenience of counting the degrees cut by the Index rather than by the Needle, as here you see 10 minutes are left in estimation, which the Index giveth more precisely, nay, sometimes you may possibly misse half or a whole degree by the Needle.

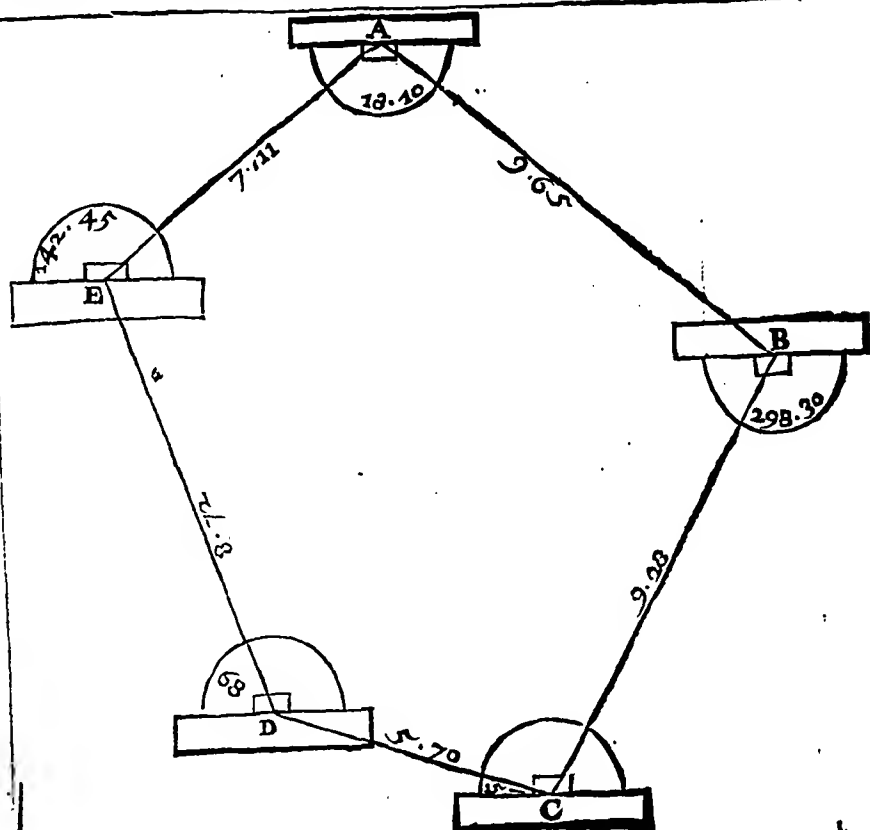
2 Place your Instrument at B, laying the Index on the diameter thereof, and turn the Instrument about till the Needle hang over the Meridian line in the Card, then fixing the Instrument there, turn the Index and sights to C, so shall both the Needle in the Box and the Index on the frame of the Table cut 298 degrees 30 minutes and measuring the distance B C, you shall find it to contain 7 Chains 28 Links, the degrees and minutes, and the length of the line measured, must be noted down in your field-book as before.

3 Place your Instrument at C, and lay the Index and sights upon the diameter thereof, then turn the Instrument about till the Needle hang over the Meridian line, then fixing it there, turn the Index about till through the sights you espie the fourth angle at D, then will both the Needle and Index cut 15 degrees 40 minutes these degrees and minutes, with the measured distance C D 5, Chains 70 Links, must be set down in your field-book.

4 Your Instrument being placed at D, with the Index on the diameter thereof, turn it about till the Needle hang over the Meridian line, and there fixing it, turn the Index about till through the sights you see the next angle at E, then will both the Needle and Index cut 68 degrees, and the distance G E will be 8 Chains 72 Links, which note in your field-book as before.

5 Lastly, place your Instrument at E, (observing all the former cautions) and direct the sights to A, where you shall finde both the Needle and Index to cut 142 degrees 45 minutes, and the measured distance E A to be 7 Chains 11 Links, which note down in your field-book.

And thus may you go about any field, let it consist of never so many sides and angles, observing alwayes this general rule to lay the Index with the Box and Needle, on the diameter of the Table, and to turn the Table about till the Needle hangs directly over the meridian line in the Card, and then fixing the Table, turn the Index about till through the sights you espie the mark you looke for, then will both the Index and the Needle cut the degrees which you must note in your field-book, so will the collected notes of this example stand as followeth.



	Degrees	Minutes	Chains	Links
A	218	10	9	65
B	298	30	9	28
C	15	40	5	70
D	68	00	8	72
E	142	45	7	11

Having thus collected your severall observations, you may proceed to protract your work as is taught in the next Chapter, which differeth nothing from that in the 36 Chap.

It will be here objected by the affectors of the Peractur, that here it is required that the Needle should play twice at each observation, to which I answer, it is true but if you neglect the later of them; it is both as speedy and as exact as the Peractur, and if you have opportunity to observe both (which you may conveniently do) it will then be better.

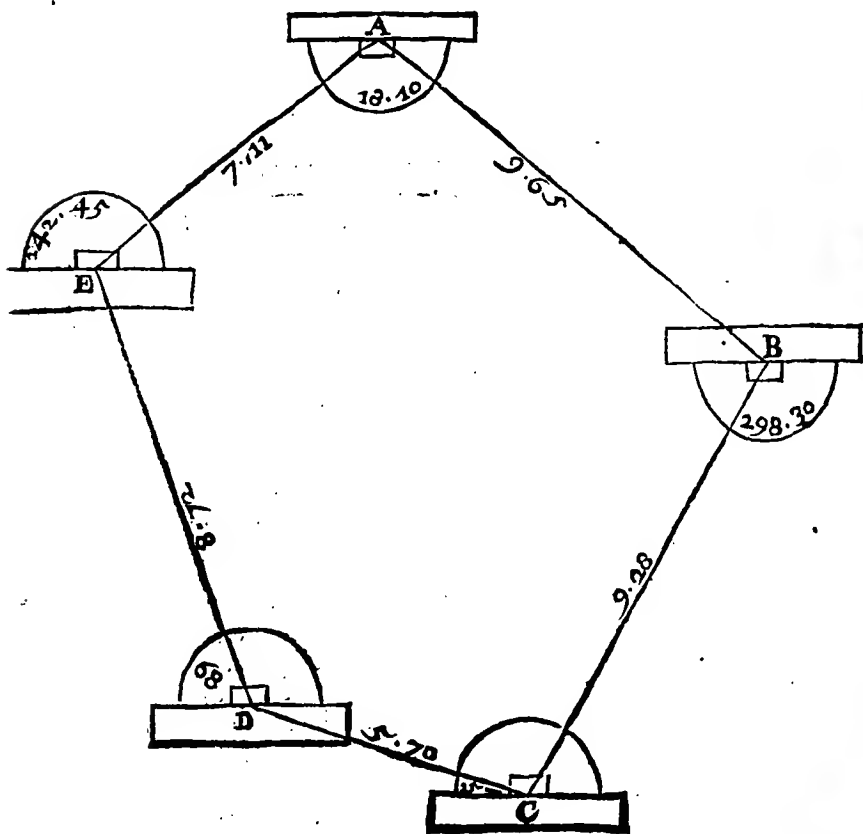
CHAP.

CHAP. XXXVIII.

How to protract any observation taken as in the last Chapter.



You must first rule your paper or parchment all over with parallel lines or Meridians, as is taught in the 36 Chapter, and upon one of these Meridians assigne any point at pleasure, as A, then laying your field-book before you, place the center of the Protractor upon the point A, the Scale thereof lying upon, or parallel to, one of the meridians ruled on your paper, and because the degrees cut at A were above 180 degrees, viz. 218 degrees 10 minutes, therefore lay the Semicircle of the Protractor downwards, and against 218 degrees 10 minutes of your Protractor make a mark, through which mark and the point A draw the line AB, containing 9 Chains 65 Links.



2. Remove your Protractor to the point B, which represents your second station or angle, laying the Meridian line thereof upon (or parallel to) one of the Meridians drawn upon the paper, and because the degrees cut at B are above 180, lay the Semicircle downwards as before, and against 298 degrees 30 minutes make a mark, and through it draw the line B C containing 9 Chains 28 Links.


3. Bring your Protractor to C, and lay it parallel to some one of your Meridians, and because the degrees observed at C were under 180, namely 15 degrees 40 minutes, lay the semicircle upwards, and against 15 degrees 40 minutes make a mark, drawing the line C D containing 5 Chaines 70 Links.

4. Place your Protractor as before upon the point D, with the Semicircle upwards, and against 78 degrees thereof make a mark, and draw the line D E containing 8 Chains 72 Links.

Lastly, Remove your Protractor to E, placing it as before, and against 142 degrees 45 minutes (which were the degrees observed at your station at E) make a mark, and through it and the point E draw the line E A, which (if your work be true) will passe through the point A, and will contain 7 Chains 11 Links.

CHAP. XXXIX.

How to take the plot of an Irregular field without any other Instrument but the Chain: and by your Scale to protract the same upon paper.

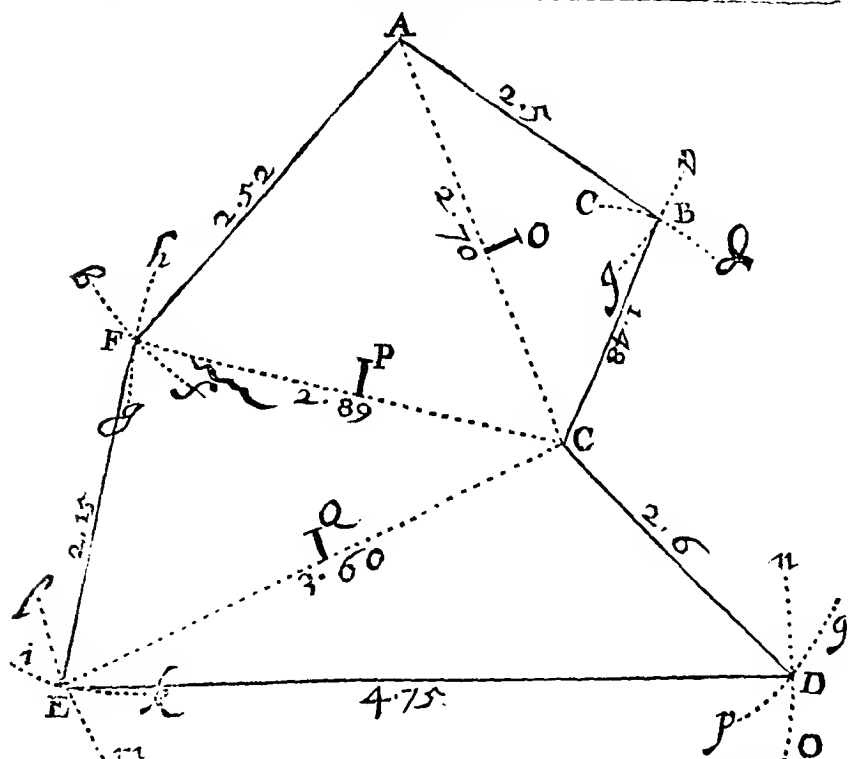
 His way of taking the plot of a field (if it be carefully practised) is inferior to none of the ways formerly taught, though it be something tedious: Neither can it be practised upon Wood-lands, large Commons, Chafes, Forrests, or Mountainous lands, but upon small inclosures only, the manner of effecting it is as followeth:

Let A B C D E F, be a field to be plotted, First, measure every side thereof beginning at the angle A, so shall you finde,

The side A B to Contain 2 Chains 5 Links

B C	1	48
C D	2	6
D E	4	75
E F	2	15
F A	2	52

Now because the field consisteth of six sides it may therefore be reduced into two Trapezias, and best (in this figure) by a line supposed to be drawn from the angle F to the angle C, by which supposed line which being measured will contain 2 Chains 89 Links, the whole field is divided into the two Trapezias A B C F, and F C E D.



Then again, if you measure with your Chain from C to A, which will contain 2 Chains 70 Links, and from C to E, which contains 3 Chains 60 Links, you shall divide those two Trapezias each into two Triangles, viz. the Trapezia A B C F into the Triangles A B C, and A C F: And the Tapezia F C E D into the Triangles F E C, and C D E. In every of which Triangles you have all the sides given, by help whereof you may upon paper or parchment, draw the exact figure of your field according to what Scale you please, in manner following.

First (taking into consideration the situation of your field) upon your paper draw the line A C containing 2 Chains 70 Links of any Scale, Then, because the side A B contains 2 Chains 5 links, take 2 Chains 5 Links from the same Scale, and placing one foot in A with the other describe the arch *ab*. Likewise, because the side B C contains 1 Chain 48 Links take one Chain 48 Links from the Scale, and placing one foot of the Compasses in C, with the other describe the arch *cd*, crossing the former arch *ab* in the point B, then drawing two lines from C and A, to the point B, you have protracted the Triangle A B C.

Secondly, For the Triangle A F C, because the side A F contains 2 C. 52 L. take 2 C. 52 L. out of your Scale, and placing one foot in A, with the other describe the arch *ef*. Likewise, because the side F C contains 2 Chains 89 L. take 2 C. 89. L out of your Scale, and placing one foot of your Compasses in C, with the o-

ther

ther describe the arch gh , cutting the former arch ef in the point F , then drawing two lines from A and C to the point F , you shall enclose the Triangle AFC .

Thirdly. For the Triangle $FE C$, because the side FE contains 2 Chains 15 Links, take 2 Chains 15 Links out of your Scale, and placing one foot in F , with the other describe the arch ik . Likewise, because the side CE contains 3 Chains 60 Links, take 3 Chains 60 Links out of your Scale, and placing one foot in C , with the other describe the arch lm crossing the former arch ik in the point E , then drawing two lines from the points F and C , to the point E , you shall inclose, the Triangle $FE C$,

Lastly, For the Triangle CED , because the side ED contains 4 Chains 75 Links take 4 Chains 75 Links out of your Scale, and placing one foot in E , with the other describe the arch no ; likewise, because the side CD , contains 2 Chains 6 Links, take 2 Chains 6 Links out of your Scale, and placing one foot in C , with the other describe the arch $p q$ cutting the former arch no in the point D , then drawing two lines from the points C and E to the point D , you shall inclose the Triangle CED , and so is your worke finished.

Although this way be somewhat tedious, yet if it be but carefully performed it will effect the thing intended with much exactnesse, and the chiefe caution to be observed in the performance hereof is, that when you measure any of the diagonals, as CA , CF , or CE , you carry your Chain in a direct line, which you may easily do if you cause a marke to be set up at each opposite angle, and a stick or such like in the mid-way between the two angles, as (in this Example) if 3 sticks or marks were erected in the Diagonals at the letters O , P , and Q .

CHAP. XL.

The use of the Instrument described in the fifth Chapter of the second Booke, as also of the Crosse mentioned in the sixth Chapter.



Having in the 37th. Chapter of this Book shewed how to make the degrees on the frame of the Plain Table to supply the use of the Instrument which Master Rathbourn so highly commendeth, and calleth by the name of the Peractur, I thought good in this place to intimate that the Instrument mentioned in the fifth Chapter of the second Book will effect this Worke as well as the degrees on the frame of the Table, and for portability exceedeth any of the forementioned, The use of this Instrument is

so obvious, that I shall not need to give any particular example concerning the use thereof, it being the same that is already taught in the use of the Theodolite, and Circumferentor only you have this advantage, that your needle is much longer, and the degrees much larger then can be in any ordinary Card.

In the sixth Chapter of the second Book there is mention made of an Instrument called a Crosse, which Instrument may be of good use in small inclosures, which consist of few sides and angles, the Instrument hath no graduations upon it, but is only to lay out right angles in the field it self without protracting, and so to cast up the content of any such field by right angled parallelograms, or long squares, and Triangles, the Instrument at the first reducing the field into the largest right angled parallelogram that may be.

CHAP. XLI.

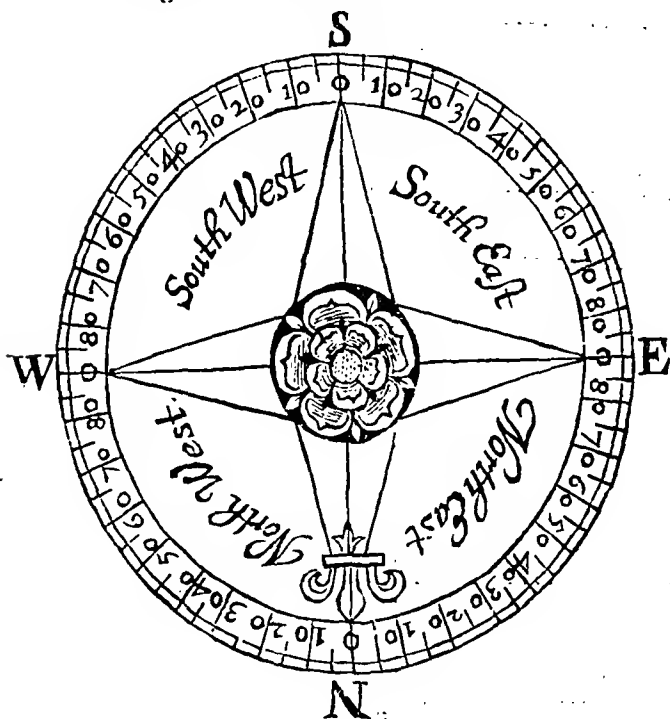
How to take the true plot of a Forrest, Chase, Wood, Park, or other large inclosure, by the Circumferentor, by a more exact way then the former, by which you may know before you begin to protract, whether your Plot will close or not, and also discover wherein you have erred, so that you may go over that part again, and examine the truth of your worke before you go out of the field.



Or the performing of this Worke, the Card of the Circumferentor, (or the degrees on the frame of the plain Table) must be divided into four Quadrants or Quarters, each containing 90 degrees, and numbered by 10, 20, 30, &c. to 90, beginning at the Meridian, and so reckoning to the East and West points, as in this figure.

Your Instrument being provided with such a Card as this figure representeth, you may proceed to take the plot of the ground you intend in manner following; but first provide your field-book which (in this case) must be ruled with red inke into six Columns, the first of which must be so broad, as to contain the number of degrees, and the quarter of the Compass in which the degrees are cut by the South end of the Needle, the second Column is for the Chains and Links which every side of the field containeth, the four other Columns which have written at the head thereof *North, South, East, West*, are to hold a certain number of Chains and Links, by the addition of which, you may examine your worke and discover whether it will close or not before you proceed to protraction.

The figure of the Card of the Circumferentor.



The manner of working.

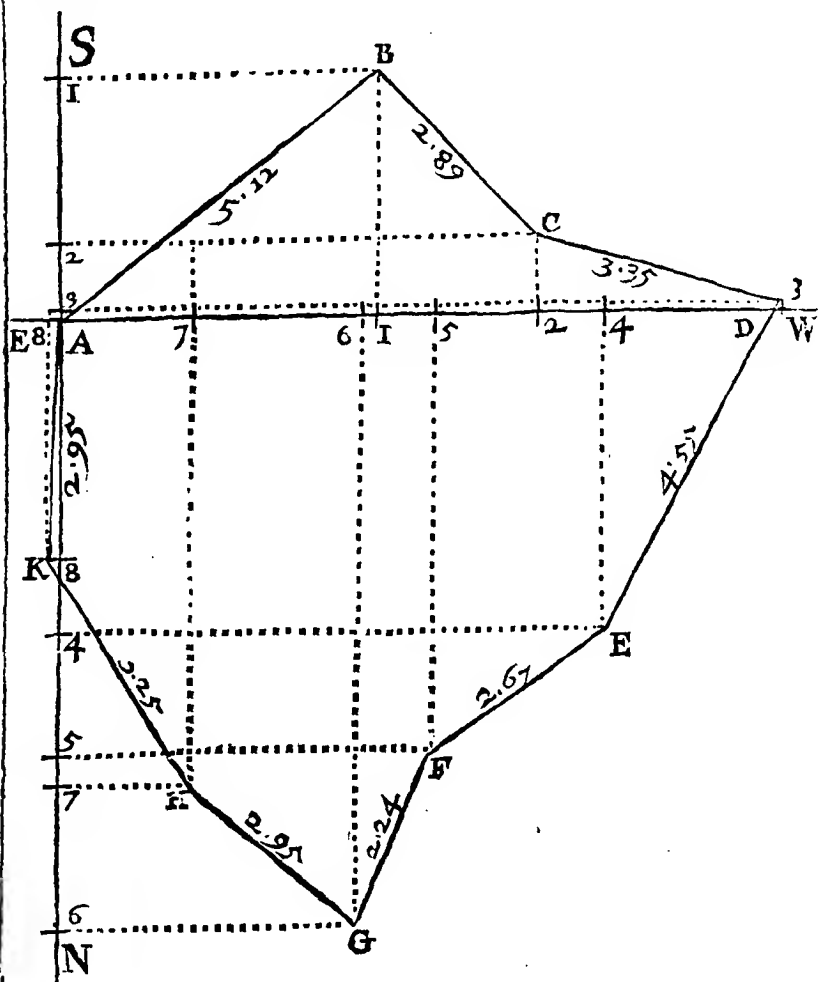
Let A B C D E F G H K be a field to be measured; having placed marks at every angle thereof, First, place your Instrument at A, (the flower deluce towards you) and direct the sights to B, the South end of the Needle cutting 54 degrees in the South-west Quadrant, and let the length of the line A B, be 5 Chains 12 Links, Now you must (in the first column of your field-book) set down S W 54 deg. 0 min. representing *South-West* 54 degrees 0 minutes, and in the second Column set down 5. 12 representing 5 Chains 12 Links.

Secondly, place your Instrument at B, and direct the Sights to C, the needle cutting *North West* 45 degrees, and the line B C containing 2 Chains 89 Links.

Thirdly, place your Instrument at C and direct the Sights to D the needle cutting North West 76 degrees, and the line C D conteining 3 Chains 35 Links.

Fourthly, place your Instrument at D & direct the sight to E, the needle cutting *North East* 31 degrees: and the line D E conteining 4 Chains 55 Links.

Fifthly, place your Instrument at E and direct your sights to F, the needle cutting *North East* 56 degrees, and the line E F conteining 2 Chains 67 Links.



Sixthly, place your Instrument at F, and direct the sights to G, the needle cutting *North East* 21 degrees and the line F G containing 2 Chains 24 Links.

Seventhly, place your Instrument at G, and direct the sights to H, the needle cutting *South East* 51 degrees, and the line G H containing 2 Chains 95 Links.

Eighthly, place your Instrument at H, and direct the sights to K, the needle cutting *South East* 34 degrees, and the line H K containing 3 Chains 25 Links.

Lastly, place your Instrument at K, and direct the sights to A, the Needle cutting *South West* 4 degrees, and the line K A containing 2 Chains 95 Links.

Having thus made observation of all the angles and measured all the sides with your Chain and set them down in your field book, you shall finde them to stand as followeth.

The

The figure of your field Boock

		deg. min.	C.L.	North	South	East	West
A	S W	54 00	5.12				
B	N W	45 00	2.89				
C	N W	76 00	3.35				
D	N E	31 00	4.55				
E	N E	56 00	2.67				
F	N E	21 00	2.24				
G	S E	31 00	2.95				
H	S E	34 00	3.25				
K	S W	4 00	2.95				

How to Examine your Worke, whether you have truly wrought, or not.

Your worke being finished, the degrees cut by the Needle and the lengths of the sides measured by the Chain set down in the first and second columns of your field boock, you may proceed to protracting, but if you desire to be satisfied of the truth of your work before you go out of the field, you may by help of the lines of Sines and Numbers very speedily make tryal, and discover wherein you have erred, and amend that error before you proceed further. The proportion is this.

First,

As the Radius, or Sine of 90 degrees

is to the length of the side of the field in Chains and Links
So is the sine of the degrees cut by the Needle
to the length in the *Parallel* in Chains and Links.

Wherefore, Extend the Compasses, from the Sine of 90, to the length of the side of the field, in the line of Numbers, the same extent will reach from the sine of the degrees cut by the Needle, to the length in the parallel.

Secondly,

As the Radius, or sine of 90 degrees

is to the length of the side of the field in Chains and Links;
So is the sine of the Complement of the degrees cut by the Needle
to the length in the *Meridian* in Chains and Links;

Wherefore, Extend the Compasses from the sine of 90, to the length of the side of the field in the line of Numbers, the same extent will reach from the sine of the complement of the degrees cut by the Needle, to the length in the *Meridian*.

☛ Note that the two columns in your field boock which are noted with North and South, are the *Meridian* columns, and the two columns noted with East and West are the *Parallel* columns, that

that is to say, the line of North and South, noted in the following figure with N S, is called the *Meridian*, and the line noted with E W in the same figure is called the *Parallel*.

EXAMPLE.

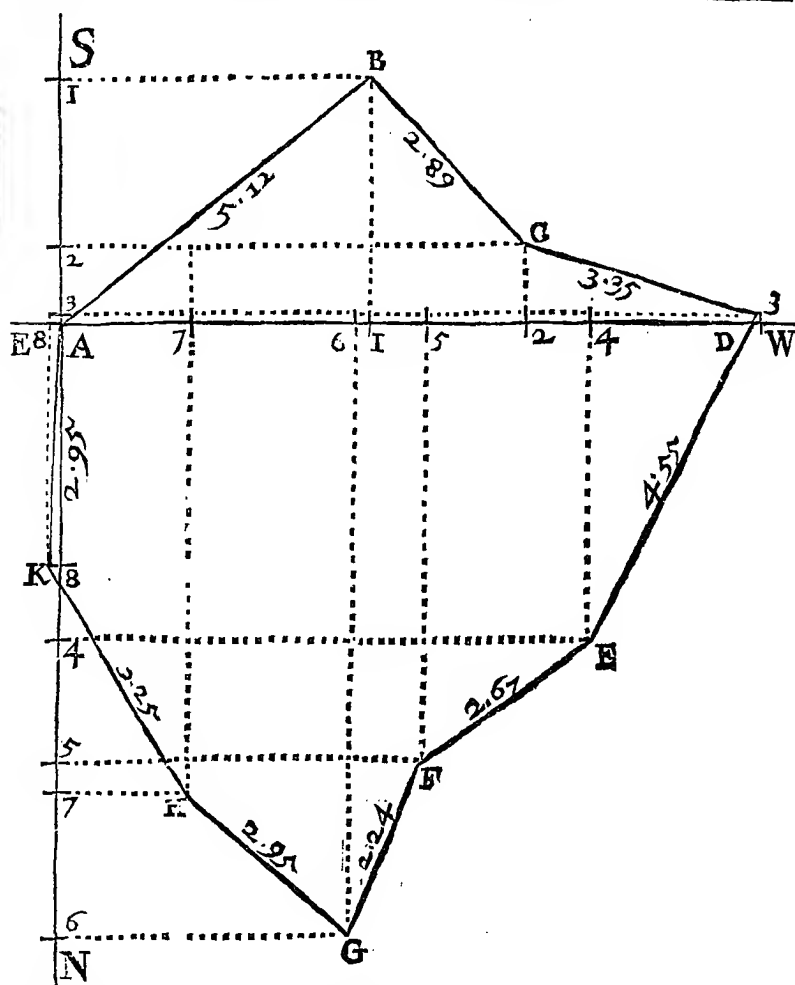
Let it be required to examine whether the degrees be rightly taken, and the sides truly measured in this figure, before you begin to protract.

Your deg. being noted and your lengths of lines orderly placed in your field book, we proceed to examine the truth thereof thus.

First, The degrees cut by the Needle when the Instrument was placed at A being S. W. 54 degrees, and the length of the line A B, being 5 Chains 12 Links, if you extend the compasses from the line of 90 degrees, to 5 Chains 12 Links in line of Numbers, that extent will reach from the Sine of 54 degrees (which were the degrees cut by the Needle at A) to 4 Chains 14 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the line of 36 degrees (which is the complement of the degrees cut by the needle at A) to 2 Chains 97 Links, in the line of Numbers, which is the distance in the Meridian, wherefore (because the quarter of the Compass was *South West*) set 4 Chains 14 Links (which is the distance in the parallel) in the Column of *West*, and also set 2 Chains 97 Links (which is the distance in the Meridian in the Column of *South*, and so have you done with your first Station at A.

Secondly, The degrees cut by the Needle, when the Instrument was placed at B being N. W. 45, and the length of the line B C being 2 C. 89 L. if you extend the Compasses from the line of 90 deg. to 2 Ch. 89 Lin. in the line of Numbers, that extent will reach from the Sine of 45 degrees, which were the degrees cut by the Needle at B, to 2 Chains 4 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 45, which is the complement of the degrees cut by the Needle at B, to 2 Chains 4 Links in the line of numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compass was *North West*) set 2 Chains 4 L. (which is the distance in the parallel) in the Column of *West*, and also set 2 Chains 4 Links (which is the distance in the Meridian) in the column of *North*, and so have you done with your second Station at B.

Thirdly, the degrees cut by the Needle, when the Instrument was placed at C being N. W. 76, and the length of the line C D, being 3 Chains 35 Links, if you extend the Compasses from the Sine of 90 deg. to 3 Chains 35 Links in the line of Numbers, that extent will reach from the line of 76, which were the degrees cut by the Needle at C, to 3 Chains 25 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine 14, which is the complement of the degrees cut by the Needle at C, to 0 Chains 83 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (because



(because the quarter of the Compass was, *North west* set 3 Chains 25 Links (which is the distance in the parallel) in the Column of *west* and also set 0 Chains 83 Links, (which is the distance in the Meridian) in the column of *North*, and so have you done with your third Station at C.

Fourthly, The degrees cut by the Needle when the Instrument was placed at D, being N. E. 31 degrees, and the length of the line D E, being 4 Chains 55 Links, if you extend the compasses from the sine of 90 degrees, to 4 Chains 55 Links in the line of Numbers, that extent will reach from the Sine of 31 degrees (which were the degrees cut by the Needle at D) to 2 Chains 35 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the sine of 59 degrees (which is the complement of the degrees cut by the Needle at D) to 3 Chains 93 Links, in the line of Numbers, which is the distance in the Meridian, wherefore (because the quarter of the Compass

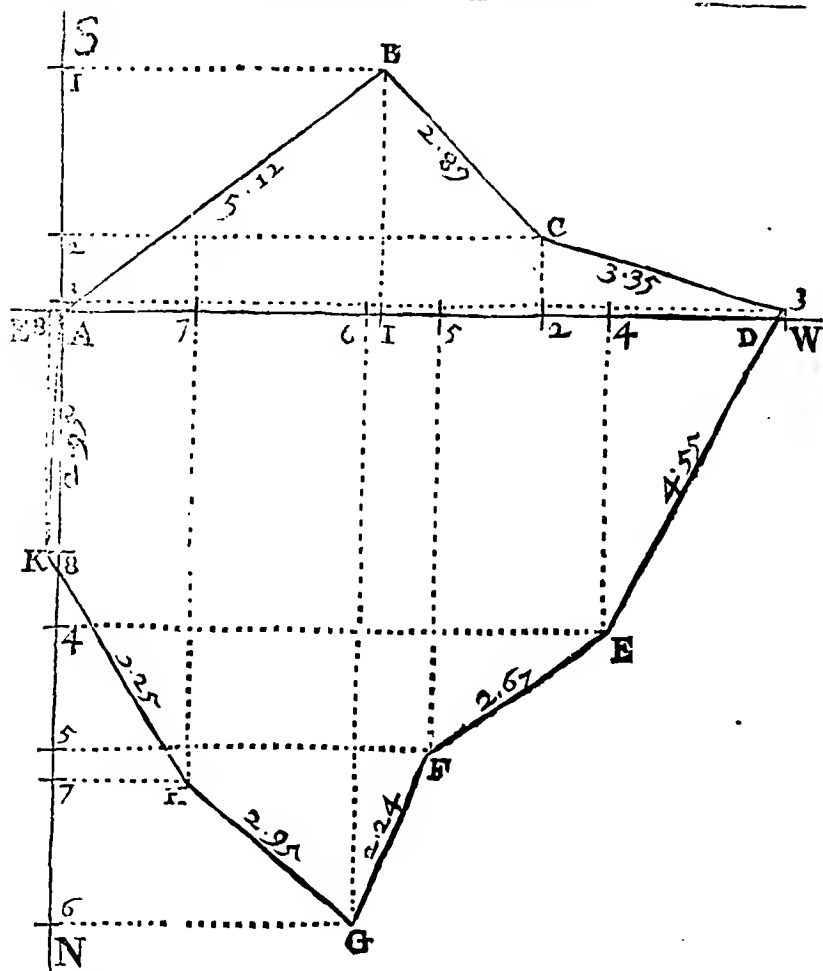
was *North East* set 2 Chains 35 Links (which is the distance in the parallel) in the Column of *East*, and also set 3 Chains 93 Links (which is the distance in the Meridian) in the Column of *North*, and so have you done with your fourth Station at D.

Fifthly, The degrees cut by the Needle, when the Instrument was placed at E being N.E. 56, and the length of the line E F being 2 Chains 67 Links if you extend the Compasses from the sine of 90 degrees to 2 Chains 67 Links in the line of Numbers, that extent will reach from the Sine of 56 degrees, which were the degrees cut by the Needle at E, to 2 Chains 22 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 34, which is the complement of the degrees cut by the Needle at E, to 1 Chain 50 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compass was *North East*) set 2 Chains 22 Links (which is the distance in the parallel) in the Column of *East* and also set 1 Chain 50 Links (which is the distance in the Meridian) in the column of *North*, and so have you done with your fifth Station at E.

Sixthly, the degrees cut by the Needle, when the Instrument was placed at F being N. E. 21 deg. and the length of the line F G being 2 Chains 24 Links, if you extend the Compasses from the sine of 90 degrees to 2 Chains 24 Links in the line of Numbers, that extent will reach from the sine of 21 degrees which were the degrees cut by the Needle at F to 0 Chains 80 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 69 degrees, which is the Complement of the degrees cut by the Needle at F to 2 Chains 10 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, because the quarter of the Compasses was *North East*, set 0 Chains 80 Links (which is the distance in the parallel) in the column of *East*, and also set 2 Chains 10 Links (which is the distance in the Meridian) in the column of *North*, and so have you done with your sixth Station at F.

Sevently, the degrees cut by the Needle, when the Instrument was placed at G being S. E. 51 deg. and the length of the line G H being 2 Chains 95 Links, if you extend the Compasses from the Sine of 90 degrees to 2 Chains 95 Links in the line of Numbers, that extent will reach from the sine of 51 degrees, which were the degrees cut by the Needle at G, to 2 Chains 30 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 39, which is the complement of the degrees cut by the Needle at G, to 1 Chain 83 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compass was *South East*, set 2 Chains 30 Links (which is the distance in the parallel) in the Column of *East*, and also set 1 Chain 83 Links (which is the distance in the Meridian) in the Column of *South*, and so have you done with your seventh Station at G.

Eighthly,



Eightly, the degrees cut by the Needle, when the Instrument was placed at H being S. E. 34 deg. and the length of the line HK being 3 Chains 25 Links, if you extend the Compasses from the Sine of 90 degrees to 3 Chains 25 Links in the line of Numbers, that extent will reach from the sine of 34, degrees which were the degrees cut by the Needle at H, to 1 Chain 82 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 56, which is the complement of the degrees cut by the Needle at H, to 2 Chains 68 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compass was *South East*, set 1 Chain 82 Links (which is the distance in the parallel) in the Column of East, and also set 2 Chains 68 Links (which is the distance in the Meridian) in the Column of South, and so have you done with your eighth Station at H.

Ninthly, the degrees cut by the Needle, when the Instrument was placed at K being S. W. 4, and the length of the line KA, be-

ing 2 Chains 85 Links, if you extend the Compasses from the Sine of 90 degrees to 2 Chains 95 Links in the line of Numbers, that extent will reach from the sine of 4, degrees which were the degrees cut by the Needle at K, to 0 Chains 6 Links in the line of Numbers, which is the distance in the parallel. And also the same extent will reach from the Sine of 86, which is the complement of the degrees cut by the Needle at K, to 2 Chains 92 Links in the line of Numbers, which is the distance in the Meridian. Wherefore, (because the quarter of the Compass was *Southwest*, set 0 Chains 6 Links (which is the distance in the parallel) in the Column of West, and also set 2 Chains 92 Links (which is the distance in the Meridian) in the Column of South, and so have you done with your ninth Station at K.

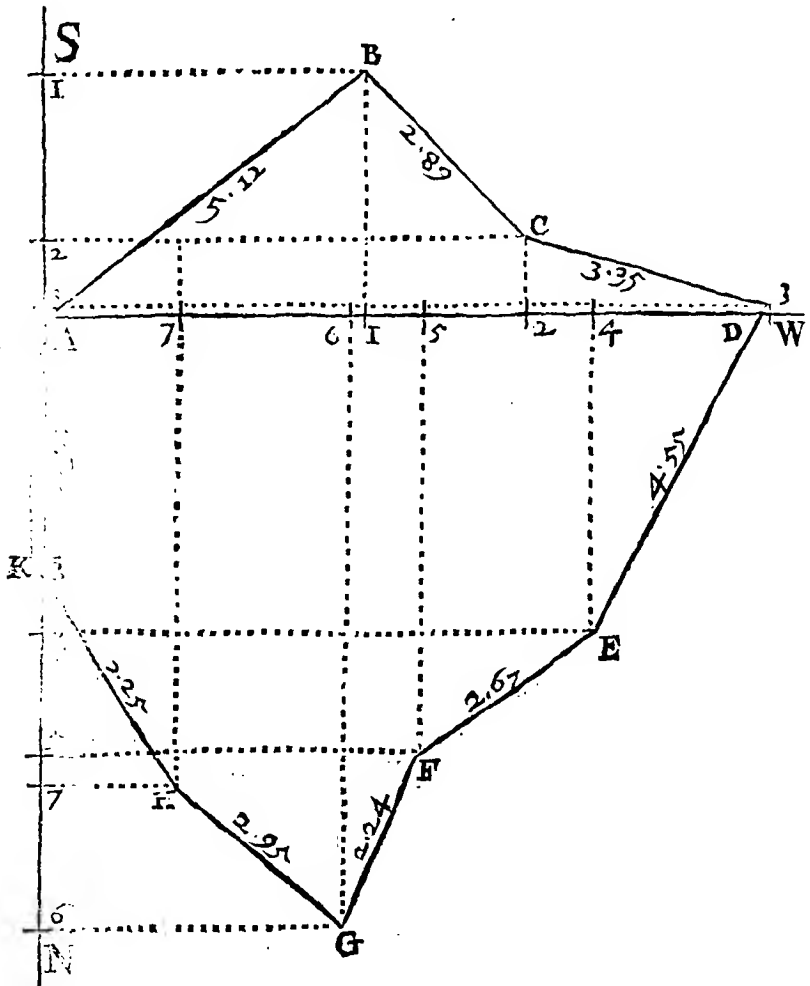
Having thus gone over every of your angles and sides, as you see here done, and noted them down in your field book under their respective Titles, of *North*, *South*, *East*, and *West*, you shall finde them to stand as followeth:

The figure of your field Book

		deg. min.	C.L.	North	South	East	West
A	S W	54 00	5.12		2.97		4.14
B	N W	45 00	2.89	2.04			2.04
C	N W	76 00	3.35	0.83			3.25
D	N E	31 00	4.55	3.93		2.35	
E	N E	56 00	2.67	1.50		2.22	
F	N E	21 00	2.24	2.10		0.80	
G	S E	51 00	2.95		1.83	2.30	
H	S E	34 00	3.25		2.68	1.82	
K	S W	4 00	2.95		2.92		0.06
Sum:				10.40	10.40	9.49	9.49

This done, adde all the figures in the North Column together, and you shall finde that they make 10 Chains 40 Links, and adde the South Column, and they make 10 Chains 40 Links also. Then adde the East Column, and they make 9 Chains 49 Links, Lastly, adde the West column and they also make 9 Chains 49 Links.

Now because the Sum of the North column, and the Sum of the South column are all one without any difference; and also the sum of the East column, and the sum of the West column also equal, you may be assured that your worke is true, but if the sums of the North and South columns, had differed your angles or sides had been falsly observed and also if the Sums of the East & West columns had differed, it had discovered an errour, but being they agree you may be assured your Worke is true, and therefore may with confidence proceed to protraction, according to the directions in the Chapter following.



CHAP. XLII.

How to extract any observations taken according to the direction of the last Chapter.



Put a sheet of Paper or Parchment draw first a line as S N, representing the *Meridian*, and at right angles thereto another line E W representing the *Parallel*. Then laying your field book before you, you shall finde in the South column 2.97, wherefore take in your **Compasses** 2 Ch. 97 L. and place it upon the Meridian from A to 1,

Secondly, in the North column you finde 2.04, take 2 Chains 4 Links in your **Compasses** and set that distance upon the Meridian from 1 to 2.

Thirdly,

Thirdly, in the North column you shall finde 0.83 take 0 Chains 83 Links in your Compasses, and set that distance upon the Meridian from 2 to 3.

Fourthly, in the North column, you shall finde 3.93 take 3 Chains 93 Links in your compasses, and set that distance upon the Meridian from 3 to 4.

Fifthly, in the North column you shall finde 1.50 take 1 Chain 50 Links in your Compasses, and set that distance upon the Meridian from 4 to 5.

Sixthly, in the North column you shall find 2.10 take 2 Chains 10 Links in your Compasses, and set that distance upon the Meridian from 5 to 6.

Seventhly, in the South column you shall finde 1.83 take 1 Chain 83 Links in your Compasses, and set that distance upon the Meridian from 6 to 7.

Eightly, in the South Column you shall finde 2.68 take 2 Chains 68 Links in your Compasses, and set that distance upon the Meridian from 7 to 8.

Ninthly, in the South column you shall finde 2.92 take 2 Chains 92 Links in your Compasses; and set that distance upon the Meridian from 8 to A, where it will exactly fall if you have truly wrought.

Thus have you found the points 1.2.3.4.5.6.7. and 8 upon the Meridian N S. through every of which points, draw obscure lines with black lead or such like, parallel to the *Parallel E W*, as the lines 1 B. 2 C. 3 D. 4 E. 5 F. 6 G. 7 H. 8 K.

This done, repair again to your field-booke where in the West column you shall finde 4 14, take 4 Chains 14 Links in your Compasses, and set that distance upon the parallel from A to 1.

Secondly, in the West you shall finde 2.04 take 2 Chains 04 Links in your Compasses, and set that distance upon the parallel from 1 to 2.

Thirdly, in the West you shall finde 3.25, take 3 Chains 25 Links in your Compasses, and set that distance upon the parallel from 2 to 3.

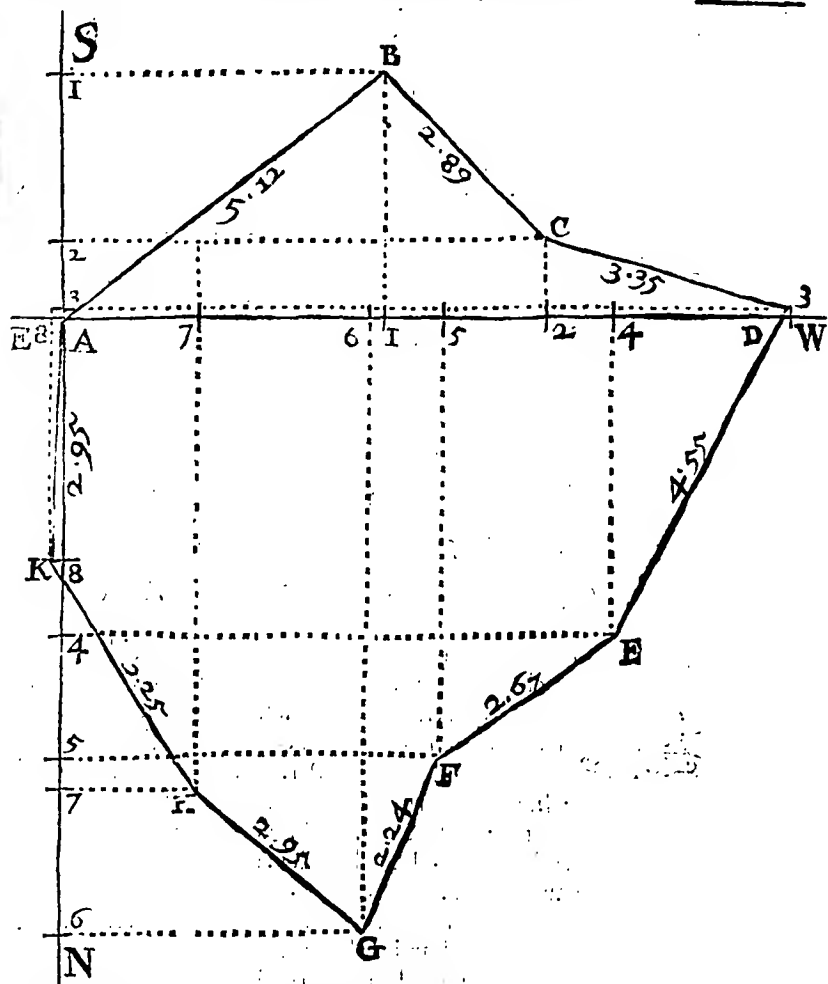
Fourthly, in the East you shall finde 2.35, take 2 Chains 35 Links in your Compasses, and set that distance upon the parallel from 3 to 4.

Fifthly, in the East you shall finde 2.22, take 2 Chains 22 Links in your Compasses, and set that distance upon the parallel from 4 to 5.

Sixthly, in the East you shall finde 0.80 take 0 Chains 80 Links in your Compasses and set that distance upon the parallel from 5 to 6.

Seventhly, in the East you shall finde 2.30, take 2 Chains 30 Links in your Compasses, and set that distance upon the parallel from 6 to 7.

Eightly, in the East you shall finde 1.82, take 1 Chain 82 Links



Links in your Compasses, and set that distance upon the parallel from 7 to 8.

Ninthly, in the West you shall finde 0.06 take 0 Chains 06 Links in your Compasses, and set that distance upon the parallel from 8 to A. where it will also exactly fall if you have truly wrought.

Thus have you found the points 1. 2. 3. 4. 5. 6. 7. 8. upon the Parallel E. W. through every of which points draw obscure lines with black lead or such like, parallel to the Meridian S N; as the lines, 1 B. 2 C. 3 D. 4 E. 5 F. 6 G. 7 H. 8 K.

This done, you shall finde that the line 1 B which is drawn parallel to the Parallel E. W. and the line 1 B which is drawn parallel to the Meridian S. N. will crosse one another in the point B, wherefore a line drawn from A to B shall represent the side of the field A B, and if you have wrought truly you shall finde it to contain 5 Chains 12 Links.

Likewise

Likewise, the lines 2 C and 2 C crosse one another in the point C
 Likewise, the lines 3 D and 3 D crosse one another in the point D
 Likewise, the lines 4 E and 4 E crosse one another in the point E
 Likewise, the lines 5 F and 5 F crosse one another in the point F
 Likewise, the lines 6 G and 6 G crosse one another in the point G
 Likewise, the lines 7 H and 7 H crosse one another in the point H
 Likewise, the lines 8 K and 8 K crosse one another in the point K

Now if you draw the lines A B. B C. C D. D E. E F. F G.
 G H. H K. and K A. you shall have upon your paper or parchment,
 the true and exact figure of the land you Surveyed, and this way
 for exactnesse, exceedeth any other that I know off.

CHAP. XLIII.

How to finde how many Acres, Roods and Perches, are contained in any piece of Land, the plot thereof being first taken by any Instrument.



Having shewn how to take the plot of any field or other inclosure several ways, and also to protra^e the same upon paper, it is now necessary to shew how the content thereof may be attained, that is to say, how many Acres, Roods and Perches, any field so plotted doth contain: In the performance hereof you must consider that the original of the mensuration of all superficial figures, such as Land, Board, Glasse or the like, doth depend upon the exact measuring of certain regular figures, as the *Geometrical Square*, the *Long Square* or *Parallelogram*, the *Triangle*, the *Trapezia*, and the *Circle*: therefore, if any plot of Land to be measured be not one of these figures, it must (before it can be measured) be reduced into some of these forms: I will therefore in the first place shew how to measure any of these figures severally by themselves, and afterwards how to reduce any other irregular figure into some of these regular forms, and lastly, to measure them by the same rules: and first,

Of the Geometrical Square.

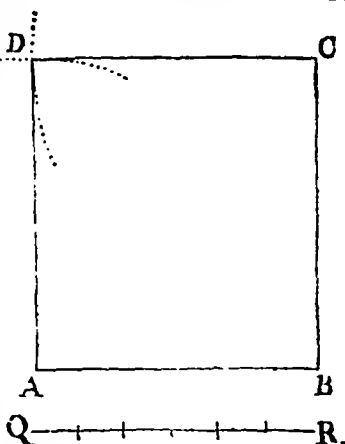
A Geometrical Square is a figure consisting of four equal sides and angles; as is the Square A B C D, whose sides are all equal to the line Q R, which containeth six equal parts, which may be attributed either to Inches, Feet, Yards, Perches, Chains, or any other measure whatsoever.

Now

Now, to find the superficial content of such a Square, you must multiply one of the sides in it self, and the product of that multiplication shall be the content of the Square.

E X A M P L E.

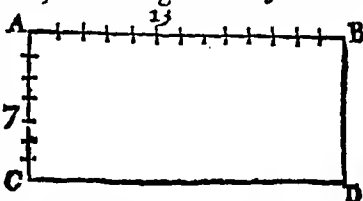
Suppose the Square ABCD to be a piece of Land, and the side thereof to contain 6 Perches, therefore multiply 6 in it self, and the product will be 36, and so many Perches doth the square piece of Land contain.



Of the long Square.

A Long Square is a figure consisting of four sides, as the figure ABCD, the two opposite sides whereof are equal, as the sides AB, and CD, and likewise AC and BD, each of the shorter sides, containing 7 Perches, & the longer sides 13 Perches.

To finde the superficial content of this long Square or Parallelogram, you must multiply one of the longer sides by one of the shorter, and the product will shew the superficial content thereof.

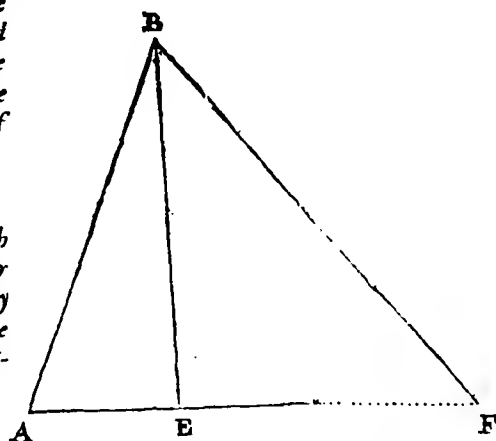


Example. The longer side of the Square contains 13 perches, and the shorter 7 perches, now if you multiply 13 by 7, the product will be 91, and that is the content of the Square in Perches.

Of the Triangle.

Although there be several kinds of Triangles, yet in respect they are all measured by one and the same rule, I will therefore add one example for all, which is general,

Half the length of the Base being multiplied by the length of the perpendicular, shall be equal to the area of the Triangle.



Or, Half the length of the Perpendicular being multiplied by the whole Base, will be the content of the Triangle.

E X A M P L E.

Suppose you were to finde the area or content of the triangle A B F, the Base thereof A F containing 58 Perches, and the perpendicular B E 24 Perches.

Now if you multiply 12 (which is half the length of the perpendicular B E) by 58 (the length of the whole base A F) the product will be 696, and that is the area or content of the Triangle.

Or, if you multiply 24 (the whole length of the perpendicular) by 29 (the length of half the base) the product will be 696 as before.

Or again: If you multiply 58 (the whole length of the base) by 24 (the whole length of the perpendicular) the product will be 1392, the half whereof is 696, the area or content of the Triangle, as before.

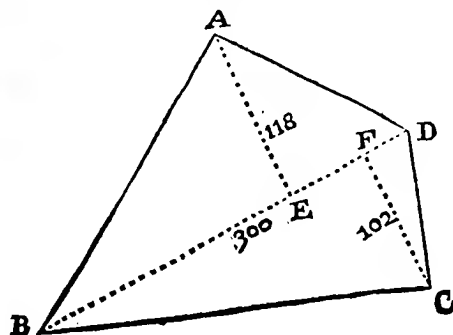
Of the Trapezia.

A Trapezia is a figure consisting of four unequal sides, and as many unequal angles, as is the figure A B C D.

To measure this Trapezia, you must first draw the diagonal line B D, for by this means the figure is reduced into two Triangles, as A D B, and C D B, then if you let fall the perpendiculars from the points A and C, you may measure them by the last examples, as two T riangles; the sums whereof being added together will be the area, or content of the whole Trapezia.

E X A M P L E.

Having drawn the line B D, and so reduced the Trapezia into two Triangles, and let fall the perpendiculars A E and C F, upon the line B D, which is the common base to both the Triangles, you may finde the area of the whole Trapezia, thus



Suppose the perpendicular C F, were 102 perches the perpendicular A E 118 Perches, and the base B D (which is common to both Triangles) 300 Perches.

Now, if according to former directions, you mul-

tiple 300 the base, by 59 half the perpendicular A E, the product will be 17700, for the content of the Triangle A B D.

In like manner, if you multiply 300 the Base, by 51, half the perpendicular F C, the Product will be 15300, for the content of the Triangle B C D.

Now if you add the contents of these two Triangles together; namely, 17700, and 15300; the sum of them will be 33000, and that is the content of the whole Trapezia A B C D.

But this work may be performed with more brevity thus.

In

thus draw lines from one angle to other, as the lines A D, D B, A F, and F H, then will the whole figure be reduced into six Triangles, as

- | | | | | |
|---|---------------------|---|---|---------------------|
| 1 | the Triangle B C D, | } | 4 | the Triangle A E F, |
| 2 | the Triangle A D B, | | 5 | the Triangle A F H, |
| 3 | the Triangle A D E, | | 6 | the Triangle F G H. |

These six Triangles being measured severally, according to the former directions, and the contents of them all added together into one sum, will shew the area or content of the whole field, As,

$$\text{Suppose the Triangle } \left\{ \begin{array}{l} B C D \\ A D B \\ A D E \\ A E F \\ A F H \\ F G H \end{array} \right\} \text{ should contain } \left\{ \begin{array}{l} 72 \\ 84 \\ 110 \\ 121 \\ 165 \\ 66 \end{array} \right\} \text{ Perches.}$$

These six numbers being added together make 618 perches, and that is the area or content of the whole Field in Perches.

But for an abbreviation of this work, you need not to finde the area of every Triangle, but of every Trapezia, as is before taught, for the figure is as well divided into Trapezias as Triangles, namely, into the Trapezias A B C D, A D E F, A F G H.

By this means you need but to finde the area or content of these three Trapezias, which will abbreviate nigh half of the Arithmetical work, for if you measure the three Trapezias severally, as hath been taught in this Chapter, you shall finde

$$\text{The Trapezia } \left\{ \begin{array}{l} A B C D \\ A D E F \\ A F G H \end{array} \right\} \text{ to contain } \left\{ \begin{array}{l} 156 \\ 231 \\ 231 \end{array} \right\} \text{ Perches.}$$

These three numbers being added together produce 618 exactly agreeing with the former.

- ¶ Here note, that at any time when you reduce any irregular plot into Triangles, your number of Triangles will be less by two then the number of the sides of your plot, as in this figure, the plot consisted of 8 sides, and you see it is reduced into 6 Triangles.

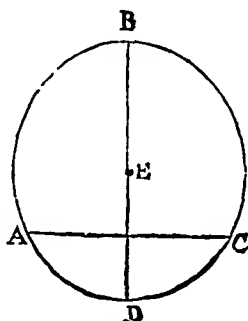
Of the Circle.

THE proportion of the Circumference of any Circle is to its diameter, as 7 to 22.

Now to finde the area or content of any Circle, you must multiply the diameter there of in it self, and multiply that sum by 11, which produ& being divided by 14, shall give you the area of the Circle.

EXAMPLE.

In this Circle A B C D, let the diameter thereof D B be 28, which multiplied in it self giveth 784, this number multiplied by 11 giveth 8624, which being divided by 14, the quotient will be 616, and that is the area of the Circle



The Circumference of a Circle being given, to finde the Diameter.

Multiply the Circumference by 7, and divide the produ& by 22, the Quotient shall be the length of the Diameter.

EXAMPLE.

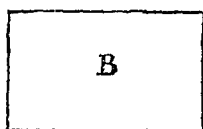
Let the Circumference of the Circle A B C D be 88, this multiplied by 7, giveth 616, which being divided by 22, giveth 28 for the Diameter D B.

CHAP. XLIV.

Of the manner of casting up the content of any piece of Land in Acres, Roods and Perches, by Ma- ster Rathborns Chain.

IN the fifth Chapter of the second Book, you have a description of Chains in general, and more particularly of Master Rathborns and Master Gunters. In the measuring of Land by Master Rathborns Chain, you call every Pole or Perch thereof (which is divided into a 100 Links) a *Unit*, and every ten of those Links you call a *Prime*, and every single Linke you call a *Second*.

Now because there are divers that fancy this Chain rather than any other, because it giveth the content of any Superficies measured therewith in its smallest denomination, namely, in Perches and parts of Perches, so that when any Superficies is cast up and brought to Perches, it may easily be reduced into Roods and Acres. Now (for their sakes that affect this Chain) I will shew the use thereof, and afterwards of Master *Gunters* Chain, leaving every man to take his choice, and use that which liketh him best.



Suppose that the figure B were a piece of Land lying in a long square, which being measured by Master *Rathborns* Chain should contain in length 16 *Unites*, 2 *Primes*; and in breadth 1 *Unite*, 3 *Primes*, 2 *Seconds*, and that it were required to finde the area or content thereof in Perches, which to effect you must

multiply the length by the breadth as is taught in the last Chapter; therefore, the length being 16 *Unites*, 2 *Primes*, and the breadth 1 *Unite*, 3 *Primes*, 2 *Seconds*, these two numbers multiplied together shall produce the area.

Set your numbers down as you are taught in the 5th Chapter of the second Book, or as you see them stand in this *Example*, with a prick over the head of every fraction: under these numbers draw a line, and multiply them together in all respects as if they were whole numbers, and then the work will stand thus,

$$\begin{array}{r}
 16\overset{\cdot}{2} \\
 \cdot\cdot\cdot \\
 11\overset{\cdot}{2} \\
 \hline
 324 \\
 486 \\
 162 \\
 \hline
 21674
 \end{array}$$

21384. Now because in your two numbers, *viz.* your multiplicand and your multiplier, there are three fractions, namely, one in your multiplicand, and two in your multiplier, you must therefore (with a dash of your pen) cut off the three last figures of the product towards your right hand, and then will your product stand thus, the three last figures whereof are the numerator of a fraction, whose denominator is 1000, and the other two figures towards your left hand are Integers of your multiplication; so that the sum of this multiplication is 21 perches, $\frac{384}{1000}$ parts of a perch, which is something more then a third part of a perch.

But to expresse the exact quantity of these fractions in a business of this nature were superfluous, onely observe this one Rule for all, namely, that if the figures cut off come neer to a *Unite*, that is, when the figures cut off are neer as much as those underneath them, or the first figure cut off is either 7, 8, or 9, you may then increase your whole number by a *Unite*, and not at all regard the fraction.

But for your further practice take another *Example*, which let be a piece of Land containing in breadth 5 *Unites*, 6 *Primes* 3 *Seconds*, and in length, 15 *Unites*, 4 *Primes*, and 2 *Seconds*, which place as before.

Now

Now if you multiply these numbers one by another as if they were whole numbers, then will they stand as in the margin, the product being 868146, from whence take the 4 last figures (because there are four fractions in your two numbers) there remains 86 perches, and $\frac{2146}{10000}$ parts of a perch; now because 8146 is near to 10000, I add 1 to 86, making it 87 perches, dis-regarding the excess as immaterial.

$$\begin{array}{r}
 1542 \\
 563 \\
 \hline
 4626 \\
 9252 \\
 7710 \\
 \hline
 8618146
 \end{array}$$

In like manner, suppose the perpendicular of a Triangle should contain 1 *Unit*, 3 *Primes*, 2 *Seconds*, and half the Length of the base should contain 16 *Units*, 2 *Primes*, these numbers being placed as those before, and multiplied one by another, will produce this product 21384, from whence cut off the three last figures (because there were three fractions in your numbers multiplied) and there will remain 21 perches, and $\frac{384}{1000}$ parts of a perch, which being but of small value you may reject.

CHAP. XLV.

How to reduce any number of Perches into Roods and Acres, or any number of Acres and Roods into Perches.

BY a Statute made the 33 of *Edw. 1.* an Acre of ground ought to contain 160 square Perches, and every Rood of Land 40 square Perches, and every Perch was to contain 16 foot and a half. Now, if any number of Perches be given to be turned into Acres, you must divide the number given by 160 (the number of perches contained in one Acre) and the quotient shall shew you how many Acres are contained in that number of Perches, and if any thing remain (if it be under 40) it is Perches; but if the remainder exceed 40, then you must divide it by 40 (the number of perches contained in one Rood) and the quotient shall be Roods, and the remainder Perches.

EXAMPLE.

Let 5267 perches be given to be reduced into Acres, first, divide 5267 by 160, and the quotient will be 32, and 147 remaining, which divide by 40, the quotient will be 3, and 27 remaining, so that the whole amounteth to 32 Acres 3 Roods and 27 Perches.

Again, let 5496 Perches be given to be reduced into Acres, first, divide 5496 by 160, the quotient will be 34, and 56 remaining, which 56 being divided by 40, the quotient will be 1, and 16 remaining, so that the whole will be 34 Acres 1 Rood and 16 Perches.

To

To reduce Acres into Perches.

THis is but the converse of the former, for (as before) to reduce perches into Acres, you divided by 160, you must now, to reduce Acres into Perches, multiply by 160.

EXAMPLE.

Let 32 Acres 3 Roods and 27 Perches, be given to be reduced into Perches: first, multiply the 32 Acres by 160, and the product will be 5120, then multiply the 3 Roods by 40, the product is 120, these two products, and the 27 Perches being added together, the sum will be 5267, and so many Perches are contained in the foresaid number of Acres, Roods and Perches: and thus much concerning the use of Master Rathbourn's Chain.

5120

120

27

5267

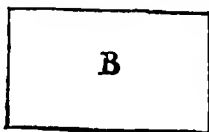
CHAP. XLVI.

How to cast up the content of any piece of Land in Acres, Roods and Perches, by Master Gunter's Chain.



IN measuring by Master Gunter's Chain, you are in your account only to take notice of Chains and Links, as was before intimated in the description thereof, *Cap. 7. Lib. 2.* Suppose then that the figure B were a piece of Land lying in a long Square, and that being measured by Master Gunter's Chain should contain in length 9 Chains 50

Links, & in breadth 6 Chains 25 Links.



Set your numbers down as before is taught & as in this Example, drawing a line under them, then multiplying them together, you shall finde the Product to be 593750, from which Product you must always cut off the five last figures towards the right hand with a dash of your pen, then will the Product stand thus, 593750, so is the 5 towards the left hand compleat Acres, and the 93750 hundred thousand parts of an Acre, which 93750 being multiplied by 4, the number of Roods in one Acre, the Product will be 375000, from which product cutting off five figures towards the right hand as before, it will stand thus, 375000, so is the 3 towards the left hand compleat Roods, and

the

the 75000 hundred thousand parts of a Rood, which being multiplied by 40, the number of Perches in a Rood, the product will be 3000000, from which cutting of the five last figures towards the right hand, the Product will stand thus, 30|00000, and the 30 towards the left hand is the number of Perches, and so the Area or content of the whole piece will be 5 Acres, three Roods and 30 Perches. Or the 93750 hundred thousand parts of an Acre may be reduced into Roods and Perches by help of the Table following.

For if you look for 90000, under the title *Links* (which is the first figure with Cyphers added) you shall find against it 3 Roods, 30 Perches, then look for 3750, and against it you shall finde 6 Perches, all which being added together as here you see, the area or content of the whole piece will be 5 Acres, 3 Roods and 30 Berches.

A.	R.	P.
5	00	00
	3	24
		6
5	03	30

Another Example.

Suppose the base of a Triangle should contain 16 Chains 56 Links, and half the Perpendicular of the same Triangle 4 Chains 32 Links, these being multiplied one in the other will produce the area or consens of the whole Triangle.

Set your numbers down as in the margin is done, and multiply one by the other, so will the Product be 715392, from which cutting off the five last figures towards the right hand, there will be left before the line of partition, which is 7 complear Acres, and behind the line there will be 15392, which are 15392 hundred thousand parts of an Acre, and how much that is, the Table easily shew; for if you looke in the first Column for 10000, against it you shall finde 00 Roods 16 Perches; then looking for 5392 you find it not, but the neereft thereto is

Mm

5625

950
625
4750
1900
1700
5 93750
4
3 75000
40
30 00000

Links.	R.	P.
100000	4	0
90000	3	24
80000	3	8
70000	2	32
60000	2	16
50000	2	0
40000	1	24
30000	1	8
20000	0	32
10000	0	16
9375	0	15
8750	0	14
8125	0	13
7500	0	12
6875	0	11
6250	0	10
5625	0	9
5000	0	8
4375	0	7
3750	0	6
3125	0	5
2500	0	4
1875	0	3
1250	0	2
624	0	1

16,56
4,31
3312
4968
6624
7 15392

A.	R.	P.	
7	00	00	5625, against which there standeth 9 Perches, all these numbers being added together will produce 7 Acres, 00 Roods, 27 Perches, which is the Area of the Triangle.
		16	
		9	
7	00	27	

Thus may you finde the area of any Triangle or Parallelogram very easily by one multiplication and addition, which is much easier then the way of casting up by Master *Rabbinus* Chain.

By this manner of work if the length and breadth of a long Square or Parallelogram given should be 9 Chains 75 Links, and 6 Chains 25 Links, the area of such a long Square would be found to be 6 Acres, 00 Roods 15 Perches. Or the length and breadth being 12 Chains, 42 Links, and 1 Chain 36 Links, the area or content will be found to be one Acre, two Roods, 30 Perches. Also, the length and breadth being 12 Chains 86 Links, and 5 Chains, 25 Links, the area will be found to be six Acres, three Roods, 00 Perches.

But lest you should be destitute of this Table when you have need thereof, you may have it put upon some spare place of your Instrument, or rather (instead of this Table) a Scale, which I will now shew you the use of, which performeth that work far better and more easily then the Table, and may conveniently be graduated upon the Index of your Table, the dividing and numbering whereof is well known to the Instrument maker.

The Scale consisteth of two parts, one whereof is square Perches, the other square Links, the Scale, of square perches proceedeth gradually from 1 to 40 with sub-divisions, and is numbred by 5, 10, 15, 20, &c. to 40. The Scale of square Links proceedeth gradually from 1 to 25000, and is also sub-divided and numbred by 1000, 2000, &c. to 25000, equal to 1 Rood or 40 Perches.

The use of the Scale of Reduction.

We will instance in the second example before-going, where the length and breadth of the long Square was 16 Chains 56 Links and 4 Chains 32 Links, these being multiplyed together produce 715392, and the five last figures being cut off, there is 7 Acres and 15392 remaining, now to finde how many Roods and Perches this is, look in the Scale of Square Links for fifteen thousand three hundred ninety two, and against it, in the Scale of square Perches you shall finde 24 Perches, and above half a Perch.

Another Example.

Let us take the first Example before-going, where the numbers multiplyed were 9.50, and 6.25, these being multiplyed one by another produce 593750, and the five last figures being cut off, there will be 5 Acres, and 93750 remaining: now to know how many Roods and Perches are contained therein by the Scale.

C You must consider that 25000 Square Links are equal to one Rood or 40 Perches, as appeareth by the Scale it self, and also by the Table, then 50000 equal to two Roods, and 75000 equal to 3 Roods; therefore, if your number remaining exceed 25000, and be under 50000, you may conclude 1 Rood and odd Perches to be contained therein. If it exceed 50000, and be under 75000, you may conclude two Roods and some odd Perches to be therein. If above 75000, you may then conclude 3 Roods and odd Perches to be therein.

Now in this Example, the number remaining is 93750, which because it exceedeth 75000, I conclude there is 3 Roods contained therein, which I set to the 5 Acres, and subtract

75000 from 93750, the remainder being 18750, *A. R. P.*
 this number, eighteen thousand seven hundred 5 3 30
 and fifty, I seek in the Scale of Square Links, and right against it I find 30 Perches, which added to the former, giveth 5 Acres, 3 Roods, and 30 Perches, which is the area or content required.

Thus you see with what celerity and exactness the Scale effecteth your desire, and therefore let it be graduated upon the Index of your Table that it may always be ready at hand when you have need thereof. The construction of this Reducing Scale I received of my honour'd Friend S.F. deceased.

CHAP. XLVII.

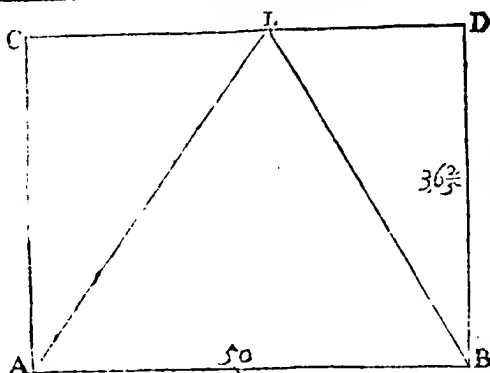
Containing divers compendious Rules for the ready casting up of the Content of any plain Superficies, and other necessary Conclusions incident to Surveying, by the Line of Numbers.



The line of Numbers is of singular use in casting up of the Content of any Superficies, and for Land measuring especially. Master Gunter hath several Propositions, like unto which, I will insert seven other Propositions which will be of singular use in the practice or Surveying.

1 *The length and breadth of a right angled Parallelogram or long Square being given in Perches, to finde the content thereof in Perches.*

As 1 Perch, is to the breadth of the Parallelogram in Perches;
 So is the length in Perches, to the content in Perches.



In this long Square or Parallelogram ABCD, if the breadth thereof CB be $36\frac{2}{3}$ Perches, and the length thereof AB 50 perches, the content will be found to be 1820 Perches: for,

If you extend the Compasses from 1 to $36\frac{2}{3}$ the length, the same extent will reach from 50 the breadth, to 1820, the area or content in Perches which you may reduce into Acres as is taught in the 41 Chap.

2 The length and breadth of a long Square being given in Perches, to finde the content in Acres.

As 160, to the breadth in Perches;

So the length in Perches, to the content in Acres.

So in the former figure, if the length thereof AB be 50 Perches, and the breadth thereof $36\frac{2}{3}$, the content will be found to be 11 Acres 40 parts, which is 1 Rood 20 Perches; for,

If you extend the Compasses from 160 to $36\frac{2}{3}$, the same extent will reach from 50 to 11 Acres 40 parts.

3 The length and breadth of a Parallelogram being given in Chains, to finde the content in Acres.

As 10, to the breadth in Chains;

So the length in Chains, to the content in Acres.

So the length of the long Square AB being 12 Chains 50 Links, and the breadth BC 9 Chains 10 Links, the area will be found to be 11 Acres, 37 parts, or 1 Rood 20 Perches, for,

If you extend the Compasses from 10 to 9 Chains 10 Links, the same extent will reach from 12 Chains 50 Links, to 11 Acres 37 parts.

4 Having the Base and perpendicular of a Triangle given in Perches, to finde the content in Acres.

As 520, to the Perpendicular;

So the length of the Base, to the content in Acres.

So in the Triangle L A B, if the line B D be taken for the Perpendicular of the Triangle, then the length of the base being 50 Perches, and the perpendicular $36\frac{1}{2}$, the area will be found to be 5 Acres 22 parts, which is 2 Roods 30 Perches, then,

If you extend the Compasses from 320 to $36\frac{1}{2}$ the Perpendicular, the same extent will reach from 50 the length of the base, to 5 Acres 22 parts.

5 *The Base and Perpendicular of a Triangle being given in Chains, to finde the content in Acres.*

As 20, to the Perpendicular,
So the Base, to the content in Area.

So in the former figure, If A B 12 Chains 50 Links be taken for the Base, and B D 4 Chains 55 Links for the Perpendicular of the Triangle A L B: the area (by this proportion) will be found to be 5 Acres 68 parts, that is, 5 Acres 2 Roods 30 Perches, therefore,

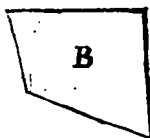
If you extend the Compasses from 20, to 4 Chains 55 Links, the same extent will reach from 12 Chains 50 Links, to 5 Acres 68 parts, which is 2 Roods 30 Perches.

6 *The Area or superficial content of any piece of Land being given according to one kinde of Perch, to finde the content thereof according to another kinde of Perch.*

As the length of the second Perch,
To the length of the first Perch;
So the content in Acres,
To a fourth number.

And that fourth number to the content in Acres required.

Suppose the figure B were a piece of Land, which being plotted and cast up by a Chain of 16 foot and an half to the Perch, should contain 8 Acres, and that it were required to finde how much



the same piece would contain if it were measured with a Chain of 18 foot to the Perch, if you work according to the proportion here delivered, you shall finde it to contain 6 Acres 72 parts; for,

If you extend the Compasses from 18 to $16\frac{1}{2}$, that extent will reach from 8 to 7.30, and from 7.30 to 6.7, and so many Acres would the figure B contain if it were measured by a Perch of 18 foot.

7 Having the length of the Furlong. to find the breadth of the Acre.

As the length of the Furlong in Perches, to 160 ;
So is 1 Acre to the breadth in Perches.

So if the length of the furlong be 50 Perches, the breadth for one Acre will be 3.20 : for,

If you extend the Compasses from 50, the length of the Furlong in Perches, the same extent will reach from 1 Acre to 3.20 Perches.

But if the length of the Furlong be given in Chains, then,

As the length of the Furlong in Chains, is to 10 ;
So is 1 Acre, to the breadth of the Furlong in Chains.

So the length of the Furlong being 12 Chains 50 Links, the breadth thereof will be found to be 00 Chains 80 Links : for,

If you extend the Compasses from 12 Chains 50 Links, to 10, that extent will reach from 1 Acre to 80 Links, which is the breadth of the Furlong required.

CHAP. XLVIII.

How to reduce one kinde of measure into another, as Statute Measure to Customary Measure, and the contrary.

BY the 6 Proposition of the last Chapter you may perform this work by the Line of Numbers as is there taught, but however, it will not be amiss in this place to shew how to perform the same Arithmetically, that the reason thereof may the better appear. Now whereas (by the fore-mentioned Statute) an Acre of ground was to contain 160 square Perches, measured by the Pole or Perch of 16 foot and a half, but in many places of this Nation (through long custome) there hath been received other quantities called Customary, as namely, of 18, 20, 24, and 28 foot to the Pole or Perch.

It is therefore necessary for a Surveyor to know how readily to reduce Customary measure to Statute measure, and the contrary.

Suppose then, that it were required to reduce 5 Acres, 2 Roods, 20 Perches, measured by the 18 foot Pole into Statute measure, you must seek out the least proportional terms between 18 foot, and 16 foot and a half, which to perform do thus. Because 16 and a half

half beareth a fraction, reduce 16 and a half into halves, and that both your numbers may be of one denomination, you must reduce 18 (the customary Pole) into halves also, then will your numbers stand thus $\frac{11}{2}$, which abbreviated by 3, by saying how many times 3 in 33? the quotient will be 11, and again, how many times 3 in 36? the quotient will be 12, so will two proportional terms between 16 and a half and 18, be 11 and 12.

This done, reduce your given quantity (5 Acres, 2 Roods, and 20 perches) into Perches, which makes 900 Perches: Now considering that what proportion the square of 11, which is 121, bears to the square of 12, which is 144, the same proportion doth the Acre of 16 foot and a half to the Perch, bear to the Acre of 18 foot to the Perch.

Now (because the greater measure is to be reduced into the lesser) multiply the given quantity 900 Perches by 144, the greater square, and the product will be 129600, which divided by 121, the quotient will be 1071 $\frac{9}{11}$ Perches, which being reduced into Acres, giveth 6 Acres, 2 Roods, 31 Perches, and $\frac{9}{11}$ parts of a Perch, according to Statute measure

But on the contrary, suppose it had been required to reduce Statute measure into Customary measure, then you must have multiplied 900 perches (your given quantity) by 121 the lesser Square, (because the lesser measure is to be reduced into the greater) the product will be 108900, which divided by the great Square 144, the quotient will be 756 $\frac{1}{4}$ perches, which reduced into Acres is 4 Acres, two Roods 36 perches and a quarter.

The same manner of work is to be observed in the reducing of any Customary quantity whatsoever.

CHAP. XLIX.

How to lay out several Furlongs in Common fields unto divers Tenants.



Having plotted the whole Field, Common, or other Inclosure, with its particular bounds, as you observe them in the survey of the whole Manor, or if you only survey that particular, you must take special notice of all the bounds thereof, then provide a Book or paper which must be ruled or divided into 8 columns, in the first whereof towards the left hand is to be written the Tenants name, and the tenor by which he holds the same Land, the two next columns are to contain the length of every mans Furlong in Chains and Links. In the two next columns is expressed the breadth of every mans Furlong in Chains and Links, as by the Letters over the head of each Column doth appear.

In the three last Columns is to be expressed the quantity of each Tenants Furlong in Acres, Roods and Perches.

In the laying out of several parcels in this kind, you will have use onely of your Chain; then when you begin your work, you must first write the name of the field, and in the first column of your Book or paper, you must write the Tenants name, and the tenure by which he holds the same, from what place you begin to measure, and upon what point of the Compass you passe from thence, and observing this direction in all the rest, you may (if need require) bound every parcel.

This being noted in your Book, observe the species or shape of the furlong, whether it be all of one length or not, if of one length, then you need take the length thereof but once for all, but if it be irregular, that is, in some places shorter and in others longer, then you must take the length thereof at every second or third breadth, and expresse the same in your Book, under the title of length. As for the expressing of the several breadths, you need but to crosse over the whole Furlong, taking every mans breadth by the middle thereof, and entering the same as you passe along, but in case there be a considerable difference at either end, then I would advise you to take the breadth at either end, and find a line which shall be a proportion between them, for your mean breadth, and enter this in your Book or paper under the title of breadth.

In this manner you may proceed from one Furlong to another till you have gone through the whole field, which when you have done and noted down the several lengths and breadths in your book, you may multiply the length and breadth of every parcel together, as is taught before, and so shall you have the quantity of every parcel by it self, which quantity must be noted down in the three last columns of your Book, as in the following example appears.

Mordon Field.

The Tenants names and tenure.	Length.		Breadth.		Content.		
	C.	L.	C.	L.	A.	R.	P.
<i>Abel Johnson</i> from the pond S. E. free.	32	76	3	45	11	1	12
<i>Nicholas Somes</i> , for three lives.	30	12	2	63	7	3	30
<i>Robert Dorton</i> , for Life.	28	60	8	12	23	0	36
<i>James Norden</i> , at Will.	25	11	12	35	31	0	2

CHAP. L.

How a Lordship lying in Common Field is to be inclosed.

This Chapter was wholly omitted in the former Edition of this Book, and indeed had not been thought of in this second Edition, had not my worthy friend Master Vincent Wing (hearing my Book was in the Press, the second time) sent me word that this Chapter would be necessary to be inserted, and withall sent me in writing, the way which I might use to effect the same, which method I liking well, have made bold to insert *certum*, as he sent it to me; which take as followeth.

Short Directions shewing how a Lordship lying in Open Field, is to be inclosed.

It most commonly hapneth when a Lordship is to be improved, wherein are many Free-holders, that their ground (consisting of different Qualities) lies for the most part dispersed, and intermixt one amongst another in all parts and quarters of the Field, therefore to finde the just Quantity of every mans ground, both Arable, Ley-ground and Medow, the Surveyor is to prepare a Field-book, wherein towards the right hand of every Page, let there be three small Columns distinguished one from another by a black line made with a pen or pensile, and one greater Column towards the left hand, which shall contain the butting, bounding and number of every mans particular Lands, Leys, Doles of Medow, or the like, which being thus fitted for use, the Surveyor when he comes into the Field, is to begin in some corner thereof, as he shall finde most convenient for taking the Field in order, and then entring upon the Furlong, he shall first set down the name of the Furlong, and upon what point of the Compass he begins; next put down the name of the Free-holder, that first begins it, with the number of his Acres, against which in the first of the three lesser columns, write the length of the lands in the second put the breadth, & in the third and last, the Quantity. Which done, set down the name of the Free-holder, that lies next, and the number of his Lands, together with the length, breadth, and quantity as before; and so proceed in order till you have finished the Furlong.

Then go to the next Furlong, writing the name thereof, and where you begin, and proceed as before, and so on from Furlong to Furlong, till you have finished the Field. But to explain it further, I shall here give you a more particular draught of the Field-book.

The Survey of the Lordship of PILTON in the County
of Rutland, made in Octob. 1656.

Middle-Hill Furlong begin, South.

West Furlong begin, East.

	Long. P.	Latit. P.	Quantity. P.		Long. P.	Latit. P.	Quantity P.
John Falkner 5 lands	51.18	7.60	393.9680	Tho. Tomblinson 1 land	36.20	2.50	90.5000
Tho. Tomblinson 2 lands	49.42	3.29	150.6150	The Parsonage 4 land	34.80	8.10	281.8800
Peter Blackley 8 lands	47.10	0.16	478.5360	John Falkner 6 land	34.00	11.0	374.
Abraham Falkner 6 lands	46.70	7.12	332.5040	Peter Blackley 2 land	34.00	4.	136.
Tho. Tomblinson 1 lands	45.00	1.30	58.5000	Henry Swift 5 lands	34.00	9.20	312.8000
John Falkner 10 lands	44.15	12.00	529.8300	Abraham Falkner 4 leys	33.50	7.0	234.5000
Thomas Falks 6 lands	44.00	8.00	352.0000	The Parsonage 4 leys	33.0	7.0	231.
Andrew Cook 3 lands	43.10	4.11	176.9560	John Falkner 1ley	33.0	2.50	82.5000

South Meadow begin, East.

Red-hill Furlong begin, South.

Peter Blackley one dole	36.20	2.50	90.5000	John Falkner 3 lands.	45.00	12.0	540
John Falkner one dole	40.00	8.0	320	Abrah. Falkner 10 lands	45.00	20.0	900
Abraham Falkner 1dole	42.00	10.0	420	Tho. Tomblinson 3 lands	45.00	12.0	540
The Parson one dole	41.00	8.0	228	The Parsonage 3 lands	50.00	12.0	600
Tho. Tomblinson 1 dole	40.50	6.50	263	Peter Blackley 6 leys	50.00	20.0	1000
Tho. Falks one dole	40.00	6.00	240	Henry Swift 2 leys	50.00	5.0	250
Andrew Cook one dole	40.00	6.00	240	Thomas Falks 4 leys	50.00	10.0	500
Peter Blackley two doles	40.00	11.50	460	Andrew Cook 1 land	50.00	2.0	100
John Falkner one dole	39.50	3.00	118.5000	P. Blackley 8 lands	50.00	4.0	200

Having finished your rough Book (after this manner) you are next to make a particular of every Mans Arable, Leys, and Meadow ground severally, that so you may be ready to give a just account of what every man holds distinctly, that by help thereof you may be enabled (with the help of Arbitrators chosen to assist you) to give every man, not onely the true quantity in his Plot, but also consideration, for the Quality of his ground, as neer as may be. To which end in drawing your Particular, you are to make so many Columns as there are Free-holders, every one whereof is to be subdivided into three, so shall you have one for Arable Land, another for Ley-ground, and a third for Meadow. Then turning to the Field-book, I begin with John Falkner, and write in the particular in its proper Column, under Arable 393 P. 968 then Thomas Tomblinson 150, P. 6150, next P. Blackley, 478.5360. which I place likewise, under their names, and in their due place, and so I proceed till I have finished the Book, placing every mans Arable Leys, and Meadow in their order, which being effected, then make your *Summa totalis*, as you may see in the following Synopsis.

*A Particular of all the Arable, Leys,
and Meadow Ground in the
Lordship of Pilton, Com.
Rutland.*

<i>John Falkner</i>			<i>Tho. Tomblinson</i>			<i>Peter Blackley</i>			<i>Abraham Falkner</i>		
Arable	Leys	Med.	Arab.	Leys	Med.	Arab.	Leys	Med.	Arab.	Leys	Med.
393	82	320	150		263	478	1000	90	332	234	420
329		118	58			156		160	900		
374			90			200					
540			540								
1836	82	438	838	0	263	814	1000	550	1232	234	420
	1836			838			1000			1232	
	82			0			814			234	
	438			263			550			420	
<i>Sum tot.</i>	2356		<i>Sum</i>	1101		<i>Sum</i>	2364		<i>Sum</i>	1886	

<i>Thomas Falks</i>			<i>Andrew Cook</i>			<i>The Parsonage.</i>		
Arab.	Leys	Med.	Arab.	Leys	Med.	Arab.	Leys	Med.
352	500	240	176		240	281	231	328
			100			600		
352	500	240	276	0	240	881	231	328
	352			276			881	
	500			0			231	
	240			240			328	
<i>Sum</i>	1072		<i>Sum</i>	516		<i>Sum</i>	1440	<i>total</i>

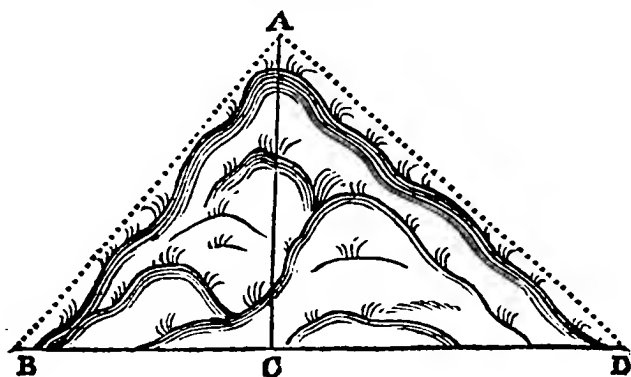
The particular being finished, I next proceed to take a general Survey, and Plot of the whole Field to be inclosed, according as hath been shewed at large in the former Chapters, which being done, you shall see if the general Survey, and the particulars agree, which if they do, you may conclude your work is exact, and then you may proceed to the plotting of every mans ground, and to lay it out in such part of the Field, as the Free-holders (or their Arbitrators) shall agree, and when that is done, you are to do in like manner with the rest, and at last when a Plot of the Town, Streets, Lanes, Houses, Woods, and all the new Inclosure, which being garnished with Colours upon Velome, or Royal-paper, will most nearly shew the true proportion and Symmetry thereof.

And lastly, Let there be a Book drawn very fair, shewing the Butting, Bounding, and Quantity of every ground, and C.

CHAP. LI.

To find the horizontal line of any hill or mountain.

THis Proposition differeth nothing from those formerly taught in the taking of Altitudes. Wherefore, suppose you should meet with a hill or mountain as ABD , the thing required is finde the length of the line BD on which the mountain standeth.



First, place your Instrument at the very foot of the Hill, exactly level; then let one go to the top of the hill at A , and there place mark, which must be so much above the top of the hill; as the top of the Instrument is from the ground; then move the Label up and down till through the sights thereof you see the top of the mark at A , and note the degrees cut by the Label one the Tangent line, for that is the quantity of the angle ABC , which suppose 47 degrees, then by consequence the angle BAC , must be 43 degrees, the complement of the former to 90 degrees, then measure the side of the Hill ABC , which suppose to contain 71 feet, then in the Triangle ABC there is given the side AB 71 feet, and the angle BAC 43 degrees, together with the right angle ACB 90 degrees, and you are to finde the side BC , which to perform, say,

As the Sine of the angle ACB , 90 degrees,

Is to the side AB : 71 feet;

So is the Sine of the angle BAC , 43 degrees,

To the side BC : 48½ feet.

Then (because the hill descends on the other side) you must place your Instrument at D , observing the angle ADC to contain 41 degrees, and the angle DAC 49 degrees, and the side AD 80 feet: now to finde the side CD the proportion will be,

As the Sine of the angle ACD , 90 degrees,

Is to the side AD , 80 feet;

So is the Sine of the angle CAD , 49 degrees,

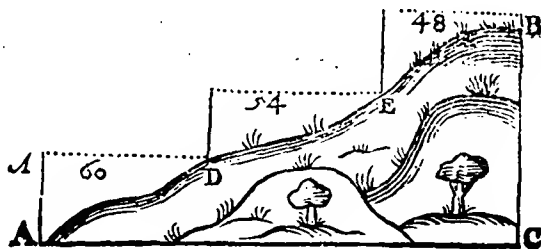
To the side CD 60½ feet.

Which added to the line BC , giveth 109 feet, which you may redu-

reduce into Chains, by dividing it by 66, and this line must be projected instead of the hypothenusal lines A B and A D.

Another way.

There is another way also used by some for the measuring of horizontal lines, which is without the taking of the Hills altitude, or using of any Arithmetical proportion, but by measuring with the Chain only, the manner whereof is thus.



Suppose A B C were a hill or mountain, and that it were required to finde the length of the Horizontal line thereof A C. At the foot of the Hill or Mountain, as at A, let one hold the Chain up, then let another take the end thereof, and carry it up the Hill, holding it level, so shal the Chain meet with the Hill at D, the length A D being 60 Links; then at D let the Chain be held up again, and let another carry it along level til it meet with the side of the hil at E, the Length being 54 Links; then again let one stand at E, & hold up the Chain, another going before to the top of the Hil at B, the length being 48 Links; these three numbers being added together make 162 Links or 1 Chain 62 Links, which is the length of the horizontal Line A C. This way of measuring is by some practised, but the other (in my opinion) is far to be preferr'd before it, only when you are destitute of better helps you may make use hereof.

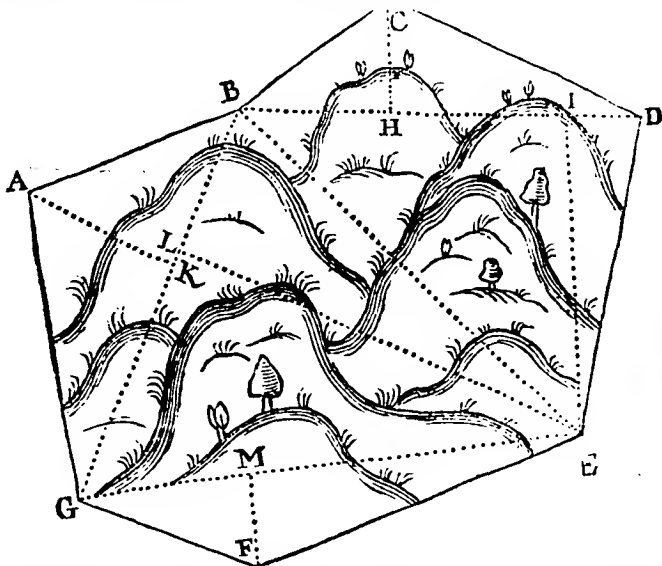
☞ But if the Hil or Mountain should have a descent back again on the other side, you must then use the same way of working as before, and add all together for the Horizontal Line.

CHAP. LII.

How to plot Mountainous and uneven grounds, with the best way to finde the content thereof.

HOr the plotting of any mountainous or uneven piece of ground, as A B C D E F G, you must first place your Instrument at A, & direct the sights to B, measuring the line A B, then in regard that from B to C there is an ascent or hill, you must finde the horizontal Line thereof, and draw that upon your Table,

Table, accounting thereon the length of the hypothenusal Line, then measure round the field according to former directions, and having the figure thereof upon your table reduce it into Trapezias, as into the Trapezias $ABEG$, $BCDE$, and the Triangle GEF ; then from the angles ACE and F let fall the perpendiculars AK , CH , EI , and FM . Now in regard there are many Hills and Valleys all over the field, you must measure with your Chain in the field over Hill and Dale from B to D , and to the Line BD set the number of chains and Links as you find them by measuring, which will be much longer then the straight line BD measured on your Scale, then by help of your Instrument finde the point H in the line BD and measure with your Chain from C to H , over hill and dale



as before, and to this perpendicular CH set the number as you find it by the Chain: then find the perpendicular IE , and measure that with your Chain also, all which Lines (in respect of the Hills and Valleys) will be found much longer then if they were measured by your Scale: then by the measured Lines BD , CH and IE , cast up the content of the Trapezia $BCDE$. In this manner you must cast up the content of the Trapezia $ABEG$, and the Triangle GEF , and this is the exactest way I can prescribe for the mensuration of uneven grounds, which being well and carefully performed, will not vary much of the true content: For it is apparent that if such mountainous grounds were plotted truly according to their area *in Plano*, the figure thereof would not be contained within its proper limits, and being laid down amongst other grounds would swell beyond the bounds, and force the adjoining grounds out of their places; now for distinction in your Plot you may shadow them off with Hills as in this figure, lest any man seeing your Plot should measure by your Scale, and finde your work to differ.

CHAP. LIIL.

How to take the Plot of a whole Manor, or of divers parcels of Land lying together, whether Wood-lands or Champion Plains, by the Plain Table.

Although practice, in the performance hereof, be better then many words, and that the rules already delivered are of sufficient extent to perform the work of this Chapter, yet (for farther satisfaction in this particular) I will herein deliver the most sure and compendious way I can imagine.

Suppose therefore that the following figure A L M N P Q S T Y X G H and K were part of a Manor, or divers parcels of land lying together, and that it were required to take the plot thereof upon your Plain Table.

Now the best way (in my opinion) is first to go round about the whole quantity to be measured, and draw upon your Table a perfect Plot thereof, as if it were one entire field (which you may do by the 31 Chapter of this Book) and then to make separation and division thereof in an orderly way, as is taught in this Chapter: But before you begin your work, it will be very necessary to ride or walk about the whole Manor, or at least so much as you are to survey, that you may be the better acquainted with the several boundaries, and in your passage you ought to take special notice of all eminent things lying in your way, as Churches, Houses, Mills, Highways, Rivers, &c. which will much help you, also in this your passage it were necessary to take notice of some convenient place to begin your work as followeth.

Having made choice of some convenient place in the periphery or outward part of the Manor, as at A, place there your Table, turning it about till the Needle hang over the Meridian line in the Card, and there fix it, then upon the Table (with most convenience) assigne any point at pleasure, as A, unto which point lay the Index, and turn it about till through the sights you see a mark set up at the next angle at L, then by the side of the Index draw the line AL, which suppose to contain 8 Chains 68 links, take these 8 Chains 68 links from any Scale, and place that length upon your Table from A to L.

2 Bring your Instrument to L, and lay the Index upon the line L A, turning the whole Table about till through the sights you see a mark set up at A where your Table last stood, and there fix it, so will the Needle hang directly over the Meridian line in the Card as before, then lay the Index upon the point L, and turn it about till through the sights you see a mark set up at the next angle at M, and draw a line by the side of the Index, which suppose to contain 6 Chains 55 links, this length being taken from the same Scale as the

your Table the figure of one large Plain; which must include all the rest of the work, and in thus going about you shall (if you have truly wrought all the way) find your plot to close exactly in the point A, where you began, but if it do not, go over your work again, for otherwise, all that you do afterwards within the same will be false.

¶ Here note, that if one sheet of paper will not contain your whole Plot, you must then shift your paper in this manner: when any Line falleth off of your Table, draw two lines at right angles cros your paper, which the equal divisions on the frame will help you to do; then lay another clean sheet of paper upon your Table, and by the same parallel divisions at the contrary end of the Table, draw two other Lines at right angles, and upon them note what part of your Plot crossed the two other Lines before drawn, and at those points begin to go forward with the rest of your work: and thus may you shift divers Papers one after another, if need be.

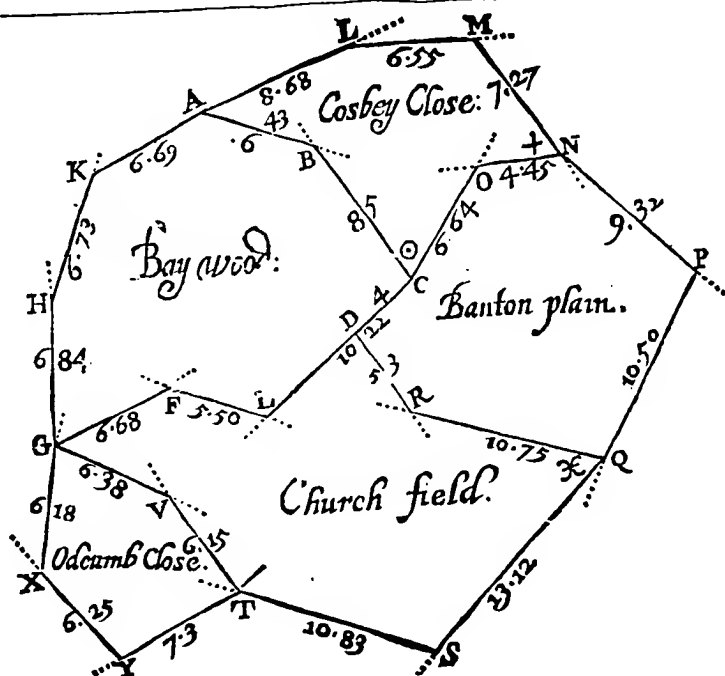
Having thus drawn the true plot of the outward bounds or periphery of the whole Manor upon your Table, as the figure ALMNPQS TYXGH and K; and exactly closed your plot at A where you began, you may proceed now to lay out the several Closes therein contained, in this manner.

1 Place your Table at A, laying the Index and sights upon the Line AL before drawn, and turn it about till through the sights you espy the angle L, and there fixing it, the Needle will hang directly over the Meridian line in the Card: then turn the Index about upon the point A, till through the sights you espy a mark set up at the angle B, and by the side of the Index draw the line AB containing 6 Chains 43 Links

2 Remove the Table to B, laying the Index on the Line BA, and turn the Table about till through the sights you see the angle A, then fix it, and turn the Index about upon B, till you see the next angle at C, drawing the line BC by the side of the Index, which suppose to contain 8 Chains 5 Links.

3 Place the Table at C, laying the Index upon the Line CB, & turn it about till through the sights you see your former station at B, and there fixing it, turn the Index about upon the point C, till through the sights you see the angle at E, and draw the line CE containing 10 Chains 22 Links, which set from C to E, and again (before you move your Table) direct the sights at O, and draw the line OC containing 6 chains 64 Links, which take from your Scale and set from C to O, and (because O is the next angle to the boundary) you may (without placing your Instrument at O, or measuring the distance ON) draw the Line ON upon your Table, which (if the rest of the work be true) will contain 4 Chains 45 Links.

4 Remove your Table to E, laying the Index upon the Line EC, and turn the Table about till through the sights you see the angle at C, then fix it, and turn the Index about upon the point E, till



you espy the next angle at F, and draw the line E F containing 5 Chains 50 Links, which set from E to F, now (because the angle at F is the next angle to the bounder) you may draw the Line F G upon your Table without any further trouble, which (if the rest of your work be true) will contain 6 Chains 68 Links.

5 Remove your Instrument to T, laying the Index upon the line T S, and turn it about till through the sights you espy the angle at S, and there fixing it, turn the Index about upon the point T, till through the sights you espy the next angle at V, and by the side of the Index draw the Line T V containing 6 Chains 15 Links, which set upon the Table from T to V: now (because V is the angle next the bounder) you may only draw the Line V G, without placing your Instrument at V, or measuring the distance V G, upon the ground, which (if the rest of the work be true) will contain 6 Chains 38 Links.

6 Bring your Instrument to Q, and lay the Index upon the Line P Q, turning the Table about till through the sights you see the angle at P, then fixing the Table there, turn the Index about upon the point Q, till through the sights you espy the angle at R, and by the side of the Index draw the Line Q R containing ten Chains 75 Links, which set from Q to R.

Lastly, Bring your Table to R, and laying the Index on the Line Q R, turn the Table about till through the sights you see the angle at Q, and there fix it, then turn the Index about upon the point R, till through the sights you espy the angle at D, and draw the Line

Line

Line R D, which (if the rest of the work be true) will contain 5 Chains 3 Links.

Thus have you an exact and perfect draught of the whole Manor, or of several Inclosures, in the performance whereof I have been something large, because I would shew the most natural way first: but the same thing may be performed with more brevity as followeth, wherein (if you mark it well) you shall plainly perceive that half the work will be abbreviated, and the same thing effected with almost half the measuring.

Having made choice of the angle A to begin your work, place your Table there, turning it about till the Needle hang directly over the Meridian Line in the Card, and there fix it, then assign any point upon the Table, for your beginning station, as the point A, and laying the Index to this point, turn it about till through the sights you espy the next angle at L, then draw the Line A L containing 8 Chains 68 Links, which take from your Scale and set from A to L: and also (before you move your Table) direct the sights to B, and by the side of the Index draw the Line A B, but you need not measure the length thereof.

2 Then go forward with your work as in the former part of this Chapter, placing your Table at the angles L M and N, and when you come to N, and have drawn the Line N P, you may (before you move your Table) draw the Line N O, but not measure it.

3 Also when you come to the angle Q, and have drawn the Line Q S, you may draw the Line Q R also, at once placing of the Table.

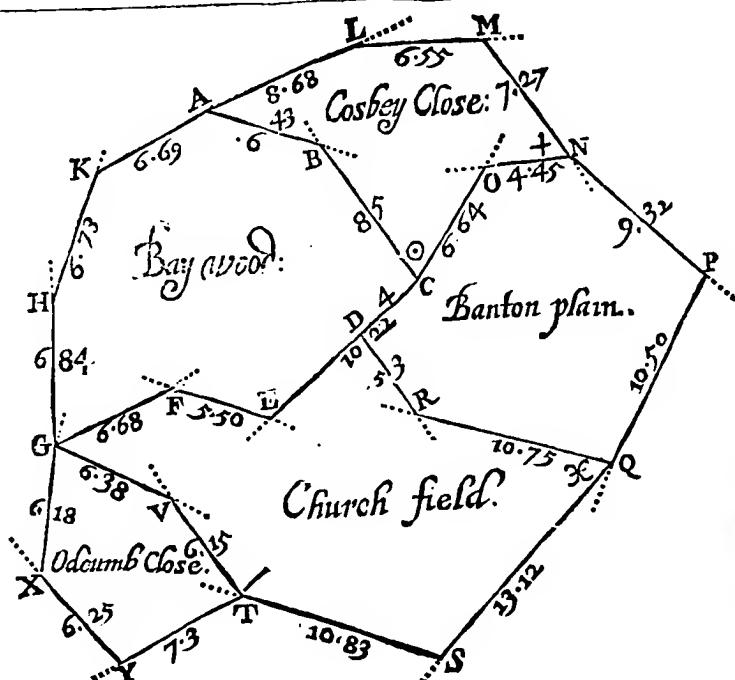
4 When you come to observe at the angle T, and have drawn the Line T Y, you may at the same time also draw the Line T V, but need not measure it.

5 When you come to the angle G, and have drawn the Line G H, you may also draw the Line G V, which will cut the Line T V in the point V; and at the same time also you may draw the Line G F containing 6 Chains 68 Links.

Having thus gone round the whole Manor, and made a Plot of the outward part or Periphery thereof, and also drawn the Lines A B, N O, Q R, T V, G V, and G F, as you went along the boulder, the remainder of the work will (by this means) be much abbreviated, for you have no more to do, but

1 To place your Table at F, laying the Index upon the Line F G, and to turn it about till through the sights you espy the angle at G, and fixing it there direct the sights to E, and draw the Line E F containing 5 Chains 50 Links.

2 Place the Table at E, and lay the Index on the Line E F, turning the Table about, till you see through the sights the angle F, then fix it, and turn the Index about upon the point E till through the sights you espy the angle at C, and by the side of the Index draw the Line E D C, which containeth 10 Chains 22 Links. Then because from C to D there is 4 Chains, set 4 Chains from C to D, and draw the Line D R, which will cut the Line Q R in the point R, leaving the Line D R to contain 5 Chains 3 Links.



Lastly, place the Table at C, laying the Index on the line CE, turning it about till through the sights you see the angle at E, and there fixing it, turn the Index about upon the point C, and direct the sights to B and O, drawing the Lines CB and CO. And thus have you upon your Table an exact plot of your Manor with great ease and celerity.

There is yet another way to perform this work : when you have taken the true plot of the outward bounds or periphery of the whole Manor upon a sheet or more of paper ; if you will take the pains to go over every particular Inclosure again, and draw particular plots of every parcel by the same Scale wherewith you laid down the Plot of the periphery; then over the Plot of every particular Inclosure, draw parallel Meridians, and when you have thus plotted every particular, if you cut them off by their bounders, and lay them one by another according to their situation within the plot of the whole periphery, you shall finde that those Plots (if your work be true) will justly fill the Plot of the whole, leaving no vacancy.

CHAP. LIV.

How to take the Plot of a whole Manor, or of divers severals whether Woodland or Champion Plains, by the Theodolite, Circumferentor, or Peracttor.

BY what hath been hitherto delivered concerning the harmony between the *Theodolite*, *Circumferentor*, and *Peracttor*, you may perceive that the working by any one of them being rightly understood, the application thereof to any of the other will be apprehended at the first sight, I will therefore instance in the *Circumferentor* as being most general. Let the example of the last Chapter serve where the figure *A L M N P Q S T V X G H K* represented part of a Manor. Then having provided your Field-book ready ruled, you must at the head of one of the leaves thereof write the Title of the Manor, the County in which it is, and who is Lord thereof, As,

The Manor of Ellimore, in the County of S.

for the Honourable R. B. Lord thereof.

Then beginning with your first Close write over the head of your Field-book the Tenants name, the name of the Close, and the tenure by which he holds the same, so for the first Close.

Henry Grey, Cosley Close, Pasture, Free.

Under this draw a Line quite through your Book, then beginning to survey this Close, place your Instrument at *A*, and direct your sights to *L*, noting the degrees there cut, which let be 160 degrees 45 minutes, which 160 degrees 45 minutes must be noted in the first and second Columns of the Field-book, then measure the distance *A L* 8 Chains 68 Links, which place in the third & 4th. Columns.

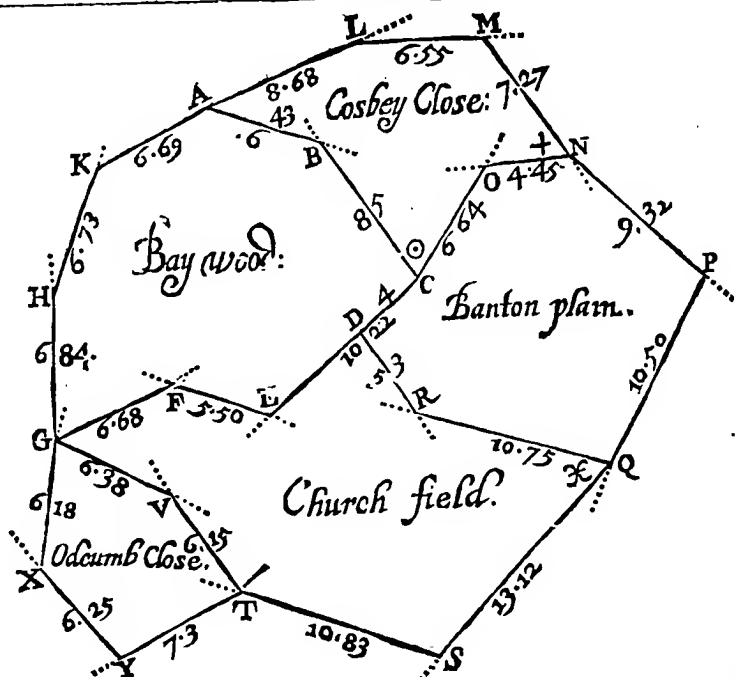
2 Remove your Instrument to *L*, and direct the sights to *M*, the Needle cutting 181 degrees 30 minutes, and the Line *LM* containing 6 Chains 55 Links, which note down in your Field-book.

3 Place your Instrument at *M*, and direct the sights to *N*, the Needle cutting 233 degrees, and the Line *M N* 7 Chains 27 Links which note in your Field-book. And in regard you are to leave the hedge or bounder *A L M N*, adjoining to *Wisly Common*, (which appertaineth to another Manor, and therefore only the name inserted for your remembrance when you come to protraction) you must draw a Line quite through your Field-book, and in the last Column thereof write *Wisly Common*, which denotes unto you that you are to leave the bounder of *Wisly Common*.

4 Place your Instrument at *N* and direct the sights to *O* the Needle cutting 355 deg. 40 min. and the distance *N O* being 4 Chains 45 Links, which note in your Field-book as before.

5 Place your Instrument at *O*, and direct the sights to *C*, the Needle cutting 309 degrees 30 minutes, and the Line *O C* containing 6 Chains 64 Links, which note in your Field-book.

Now



Now because at these two Observations you went against the hedge or bounder of *Banton Plain*, you must against them write in your Field-book *Banton Plain*, and because you are now to leave the hedge or bounder of *Banton Plain*, draw a Line quite through your Field-book.

6 Place your Instrument at C, and direct the sights to B, the Needle cutting 54 degrees 30 minutes, and the distance CB being 8 Chains 5 Links, the degrees and minutes must be noted in the first and second columns of your Field-book, and the Chains and Links in the third and fourth.

7 Remove your Instrument to B, and direct the sights to A, the Needle cutting 19 degrees 30 minutes, and the distance BA being 6 Chains 43 Links, the degrees and minutes must be noted in the first and second Columns of your Field-book, and the Chains and Links in the third and fourth. Now because at these two last observations you went against the hedge or bounder of *Bay Wood*, you must therefore against them write *Bay Wood*, and because you have now finished your first Close, you must draw a double Line through your Book for your remembrance.

Then consider which parcel is next fittest to be taken in hand, which let be *Bay Wood*, and withall at what angle thereof it is most meet to begin, which suppose C, and here for your help when you come to protraction you must express in the title of this second Close at what angle you begin the same (unless you had begun it where you ended the last at A, & then it is not material) wherefore seeing

seeing you are best to begin at C, look in your Field-book (on the work of the last Close) what degrees and minutes the Needle cut at C which were 54 degrees and 8 Chains 5 Links, therefore against that number make this \odot or the like mark, and write the Title for your second Close thus.

Samuel White, Baywood, by Lease,
begin at \odot .

By this means you shall readily know when you come to protraction, where to begin with this parcel, and in the margine place (2) for the number of your second parcel, and then proceed in your work of surveying this parcel as before you did for the other till you have gone round about the same ending at A where you first began, noting down all your observations both of lines and angles, with the particular bounders as you go along in your Field-book, in all respects as you did those of the first Close, and in thus doing you shall find that at your first observation from C to E, that you went partly by the hedge or bounder of *Banton Plain*, and partly by the hedge or bounder of *Church-field*, and therefore against the degrees of that observation write *Banton Plain* and *Church-field*, there drawing a line: then at your two next observations at E and F you went along the hedge or bounder of *Church-field*, and at the 3 last observations at G H and K you went against the hedge or bounder of *Wisby Common*, there finishing your second parcel, wherefore draw a double line quite through your Field-book.

These two parcels being finished, consider which is next fittest to be taken in hand, and where to begin it, which suppose *Banton Plain*, and to begin at N, wherefore look in your Field-book what degrees the Needle cut when you made observation at end in the surveying of *Casly Close*, and left the bounder of *Wisby Common*, which degrees you shall find to be 355 degrees 40 minutes, and 4 Chains 45 Links, therefore at the end of that Line where you find 355 degrees 40 minutes & 4 Chains 45 Links, make this $+$ or some other mark for a remembrance when you come to protraction, then for the next parcel write in your Field-book.

George Burton, Banton Plain, for two lives,
begin at $+$.

This being done place your Instrument at N. & direct the sights to P, the Needle cutting 220 degrees 20 minutes, and the line N P containing 9 Chains 22 Links, which note in your Field-book, and because at this observation you went by the hedge or bounder of *Wisby Common*, and are now to leave it, therefore draw a line and write *Wisby Common*, and in this manner must you go about this parcel also till you come to close at D, and having finished draw a double line.

Then considering that *Church field* is next fittest to be surveyed, and that it is most convenient to begin the same at Q, therefore look what degrees the Needle cut at Q in the surveying of *Banton Plain*.

*The Manor of Ellmore, in the
County of S. for the Honorable
R. B. Lord thereof.*

(1) *Henry Grey, Cusby Close, Pasture, Free.*

16	45	8 68	<i>Wisby Common.</i>
181	30	6 55	
233	00	7 27	
355	40	4 45	<i>Bacton Plain.</i>
309	30	6 04	
54	00	8 50	<i>Bay Wood.</i>
19	30	6 43	

(2) *Samuel White, Bay Wood, by Lease,
begin at O.*

320	00	10 22	<i>Bacton Plain, & Church field.</i>
15	30	5 50	<i>Church field.</i>
337	45	6 68	
87	30	6 84	<i>Wisby Common.</i>
113	30	6 73	
153	30	6 69	

(3) *George Burton, Bacton Plain, for two Lives,
begin at +.*

220	20	9 12	<i>Wisby Common.</i>
299	30	10 50	<i>The Forrest.</i>
15	40	10 75	<i>Church field.</i>
53	30	5 3	

(4) *Thomas King, Church field, by Lease,
begin at x.*

316	20	13 12	<i>The Forrest.</i>
17	15	10 83	<i>Church Lane.</i>
56	00	6 15	<i>Odcumb Close.</i>
24	10	6 38	

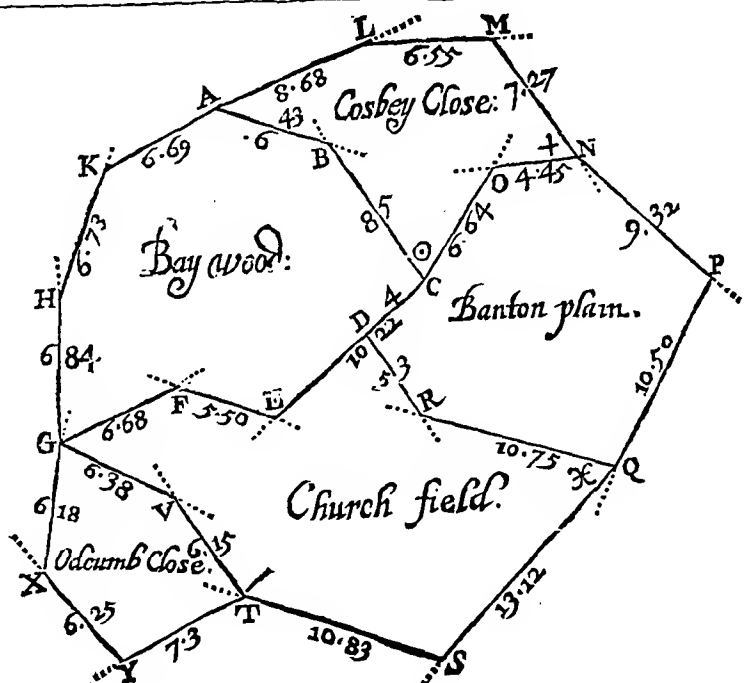
(5) *John Nichols, Odcumb Close, Free,
begin at —*

334	30	7 3	<i>Church Lane.</i>
48	30	6 25	
101	30	6 18	

These Instructions given being sufficient for the application and use of the Field-book, I shall desire every practitioner to make frequent trial & practice thereof, & compare the Book with the Plot, and protracting the same according to the directions hereafter given, you will finde it to be most exact and facile.

Here by the way, I might give directions whereby to take in divers severals at once, if the Bounders be regular, which will much ease you both in surveying & protracting, but by small practice this and divers other abbreviations will appear of themselves.

I have here added one leaf of your Field-book as it ought to be ruled, which take for an example; it being the Collections of the Worke of this Chapter: with the several Lines, Angles and bounders, as you observed them in your Survey.



CHAP. LV.

How to protract or draw the plot of a whole Manor, or of divers inclosures, the observations of the several angles, lines and bounders being noted in your Field book.

Provide a Skin of Velom, or Parchment, or divers sheets of Paper neatly fastned together with mouth-glew, according to the magnitude or greatness you intend to have your Plot, which Paper or Parchment let be ruled all over with occult parallel Lines, representing Meridians, as is taught in the 36 Chapter of this Book, the distance of which Lines one from another must not exceed the breadth of the Scale of your Protractor.

Now suppose you were to protract the observations of the last Chapter, laying your Field-book before you, consider which way your Plot will extend, and accordingly begin your work, as at the point A, upō which point A place the center of your Protractor turning it about, till the correspondent divisions at each end of the Scale of the Protractor lie directly upon one of the parallel Meridians, & staying the Protractor there, look in your field-book what deg. and min. the Needle cut at your first observation at A, which

were

were 160 degrees 45 minutes, therefore against 160 degrees 45 minutes of your Protractor make a mark, and through that mark and the point A, draw the Line AL, containing 8 Chains 68 Links.

Then place the center of the Protractor upon the point L, in all respects as before, and finding your next degrees and length to be 181 degrees 30 minutes, and the length 6 Chains 55 Links, therefore against 181 degrees 30 minutes of your Protractor make a mark, and through it draw the Line LM containing 6 Chains 55 Links.

Then place the center of the Protractor upon the point M, and look in your field-book what degrees were cut at M, protract those degrees (as before) and draw the Line MN containing 7 Chains 27 Links.

Then place the center of the Protractor upon the point N, the degrees cut being 355 degrees 40 minutes, and the Line NO containing 4 Chains 45 Links, and because against these 355 degrees 40 minutes you finde in your Field-book this mark \oplus there placed, you must therefore (with Black Lead or the like) make the same mark at the point N upon your paper, to signifie that you must there begin to protract some other Close.

In this manner must you proceed with all the other Lines and Angles, as you finde them noted in your Field-book, till you have gone over your first Close, and closed your Plot at A. Having thus finished your first Inclosure, you must deal in the same manner with the second, third and fourth, and so on, were there never so many. And to know where to begin to protract your second Inclosure, you must have recourse to your Field-book, where you shall find this mark \odot at which you must begin your second Inclosure, which is *Bay Wood*, and the like mark upon your Paper at the point C, which is your remembrancer to put you in minde that at the point C you must begin to protract your second Inclosure, as you did your first Close.

- ☛ In this manner of protracting there is no difference nor cautions to be observed, more then those already hinted in Chapter 36 and 38 of this Book *viz.* that if the degrees to be protracted be under 180, to lay the Semicircle of the Protractor upwards or from you; and if they be above 180, to lay the Semicircle downwards.

CHAP. LVI.

The figure of any plot being given, how to enlarge or diminish the same according to any assigned proportion

IT may so fall out that when you have taken the Plot of a whole Manor upon your Plain Table, in divers sheets of Paper, or observed the angles, and afterwards protracted them, as in the two last Chapters, it may so fall out that your Plot may be either bigger or lesser then is desired, now if at any time it be required to enlarge or diminish any Plot according to any proportion, this Chapter will accomplish your desire.

The Instruments for the performance hereof are divers, as was intimated in the ninth Chapter of the second Book. Now for generality and exactness, the two Indexes there spoken of, having at each end thereof a Semicircle, is inferiour to none, but the Instrument being very chargeable, and the use thereof very intricate and tedious, I shall wholly omit to speak any more of it.

There is another way also which Master *Rashborn* used, which was with a Ruler by him invented for that purpose, which would indifferent well reduce a Plot from one bigness to another according to some particular proportions. The making of this Ruler is so well known, and the use thereof so apparent, that I shall not need to say any thing concerning the description or use of it: I only intimate that there is such a Ruler, that those which please may have it made.

Another way is by one Line divided into 100 or 1000 equal parts only, which by the help of Arithmetick will perform this work very well, but this (as being very tedious) I neglect.

To pass by these and divers others which I could name, I shall say something of the Parallelogram, which for generality, exactness, and dispatch, surpasseth all the rest, unto which (in my opinion) there is none comparable. Of Parallelograms there are divers sorts, but that which I shall instance in, consisteth but of four Rulers only, the making whereof is well known to the Instrument-maker, and the manner of using it as followeth.

Take the Plot which you would reduce, and fasten it to a Table with Mouth-glew, then by it, upon the same Table, fasten your fair Paper or Parchment, upon which you would have your new Plot; then having fitted your Parallelogram according to the proportion into which you would have your Plot reduced, fix the Parallelogram to the Table, by a point for that purpose: then put your drawing Pen into some one hole on one of the sides of the Parallelogram, and upon it a plummet of lead or brass to keep the pen down close

to the paper, when it is moved thereupon: and here note, that at any time when the Parallelogram is thus fitted, the point that sticketh in the Table, the Pen which is to draw, and the Tracer which you must move along the lines of your old Plot, will lie alwayes in a right Line, but this by the way: Your Parallelogram being fixed to the Table, and the Pen in its true place fitted to draw, take the Tracer in your right hand, and with it, lightly go over all the Lines of your old Plot, so shall the motion thereof occasion the Pen to draw upon your clean paper or parchment, the true and exact figure of your former Plot, though of another bigness, which will be in proportion to the greater according to the situation of the sides of the Parallelogram; which will better appear by the sight of the Instrument, then words can possibly explain it.

¶ There is yet another way how to reduce a Plot according to any proportion assigned, and that is this. Suppose you would have a Plot diminished in proportion as 4 to three. Cause a Scale to be made, of such a length that it may reach from the center to the middle of your Plot. to the outermost angle thereof, which let be divided into 100, 1000, or 10000 parts, according to the length thereof, then let another Ruler be made, which shall be in proportion thereto as 4 to 3, which Ruler let be divided into the same number of equal parts as the other Ruler was: being thus provided of two Rulers, lay by your large Plot upon a Table, fastning it at the corners with mouth-glew; and underneath it lay your fair paper or parchment, then number all the angles in the field with Arithmetical figures, beginning with the outermost angle, calling that one the next two, the third three, and so forth, then as you move the Ruler from angle to angle, take notice what number of equal parts is cut by every angle, and note them down in paper, then take off your longer Ruler, and lay on your shorter in the place thereof, so moving it from angle to angle, and pricking holes with a smal protracting Pin quite through the old Plot, so when you have gone over every angle you may upon your clean paper or parchment draw lines from point to point, till you have gone over all the angles, so shall your Plot be reduced to your intended bigness.

CHAP.

CHAP. LVII.

How to draw a perfect draught of a whole Manor, and to furnish it with all necessary varieties, also to trick and beantifie the same: in which, (as in a Map) the Lord of the Manor may at any time (by inspection only) see the symmetry, situation and content of any parcel of his Land.

HAVING protracted your Plot according to your intended bigness, and written the content of each Close about the middle thereof, you may about the bounds of every Field or Inclosure, with a small Pencil, and some transparent green colour, neatly go over your black Lines, so shall you have a transparent stroke of green on either side of your black Line, which will add a great lustre and beaurty to your Plot.

Then in your Wood-land grounds draw divers little Trees in the most material places, and shadow your mountainous and uneven grounds with Hills and Valleys, expressing all kinde of Bogs, Groves, High-ways, Rivers, &c. distinguishing them by lively colours according to their similitudes.

Then in some convenient place of the Plot, without the Inclosures, draw a Circle, and therein describe the 32 Points of the Mariners Compass according to the situation of the grounds, with a Flowre-de-luce at the North part thereof.

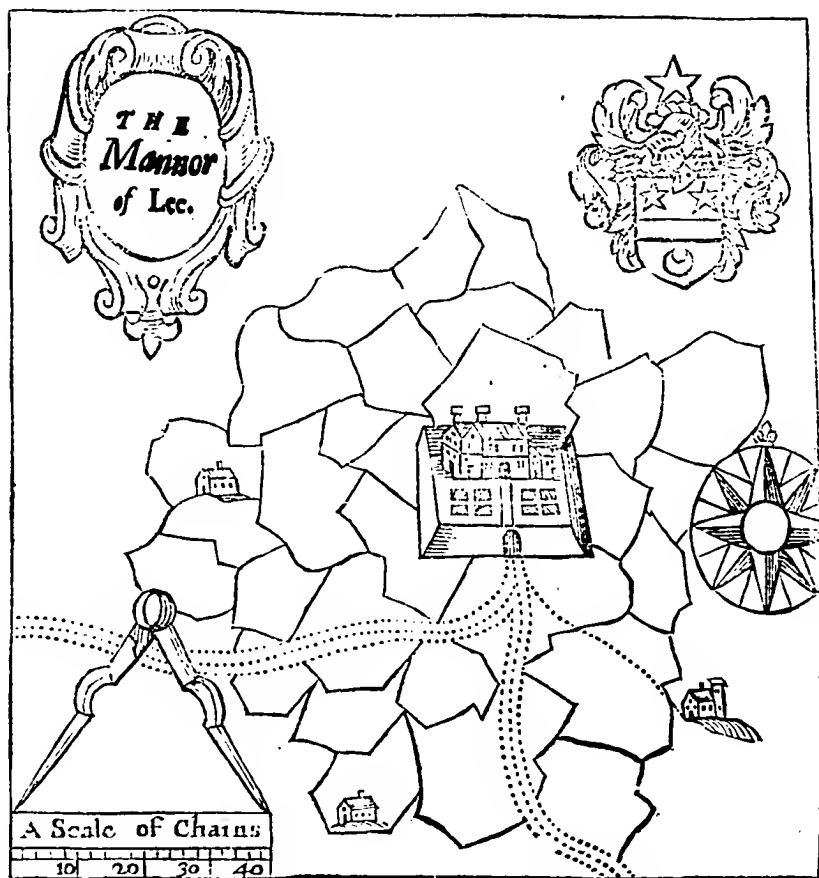
Then in some convenient place of your plot, make a Scale equal to that by which your Plot was protracted.

Lastly, in some other convenient place towards the upper part thereof, draw the Coat of Arms belonging to the Lord of the Manor, with Mantle, Helme, Crest, and Supporters; or in a Compartment, but be sure you blazon the Coat in its true Colours.

These things being well performed, your Plot will be a neat Ornament for the Lord of the Manor to hang in his Study, or other private place, so that at pleasure he may see his Land before him, and the quantity of all or every parcel thereof without any further trouble.

Also in your Plot must be expressed the Manor-house according to its symmetry or situation, with all other houses of note, also all Water-mills, Wind-mills, and whatsoever else is necessary, that may be put into your Plot without confusion.

For farther explanation of what hath been delivered in this Chapter, I have here added the figure of a small Manor, which will be sufficient for example sake.



CHAP. LVIII.

The names of such Colours as are necessary for the Washing of Maps, Charts, or Plots, with the manner how to temper and use the same upon Velom, Paper, or Parchment.

IT is not convenient for a Surveyor when he hath drawn the draught of a Manor, and reduced it to his intended bigness, to repair to a Painter to finish his work, the thing it self being very gentle, and easie to be attained: And besides a Painter is not easie to be found in every Countrey, nor is every Painter furnished with Colours fitting for such a purpose, they for the most part using more ordinary Colours, now for the benefit of such who desire to exercise themselves in this kinde of practice, I have added these necessary directions following.

I How

I How to make Gum Water.

TAKE Gum Arabeck what quantity you please, of the whitest and clearest you can get, which bruise into small pieces, and tie them up loosely in a fine linnen rag, then take of the clearest water you can get, & put it into a clean vessel, as a poringer, (or such like) then hang your Cloth in which you put your Gum in this water, letting it hang till all the Gum be dissolved, then when you put your fingers into this Water, if you finde them to stick together, as if they were glewed, your water is too stiff of the Gum, which you may remedy by putting thereto more fair water, and if you finde it too weak you may add more Gum, with this Water most Colours are to be tempered.

2 How to make Allum Water.

TAKE a pound of Allum, and beat it to powder, then take a Gallon of clean Water, and set it on a fire, letting it boil till all the Allum be melted, then take it off the fire, and when it is cold, you may put it into a vessel and keep it for your use with this water, if you wet your Paper before you lay on your Colours, it will keep them from sinking into the paper, and will also add a lustre and beauty to the Colours laid thereon.

3 The names of such Colours as are necessary for the Washing of Maps, Plots, or Charts.

Reds	Blews	Yellows	Greens
Vermilion	Bice	Gumbuege	Green Bice
Lake	Indigo	Yellow Berries	Verdegrece
Rosset	Smalt	Orpiment	distilled
Brasil	Verditer		Sap-green
Red Lead			

Umber, Lamp-black

Being thus provided of these several Colours here named, which you may have in divers places in *London*, as also of a grinding stone and Muller, which any Mason in *London* will furnish you with, also divers pencils of several sizes and Gally pots, Gar Glasses, or Horse Muscleshells, to put your Colours in when they are grounded and tempered, you are then ready at any time to make use of them, and now will I shew you how all the fore-mentioned Colours are to be ground and tempered.

How to grinde Vermillion, Lake, and Red Lead.

YOUR grinding stone and Muller being very clean, take either Vermillion, Lake, or Red Lead, and lay it upon your Stone, then take

take so much Gum-water as will wet the same, then with your Muller grinde the Vermillion, Lake, or Red Lead with the Gum-water very well together, till there be no grit left, then with a knife or a piece of Lanthorn horn take it off the stone and put it into a Gally pot or shell, and keep it for your use: if it be too thick for your use, you may at any time remedy that by putting in of more Gum water, and stirring it about with a stick or pencil, but it is most convenient to grinde no more of any Colour at a time then you shall have occasion to use.

How to prepare Brasil.

TAKE two Ounces of Brasil ground, and put thereto a pint of small Beer, and as much Beer Vineger set then on the fire, and let them boil well together, then take half an ounce of Allom and beat it very fine, also a little bit of Gum Arabeck, and put them in while it is on the fire, letting all boil to ether till the Allom and Gum be quite dissolved. then take it off and strain it through a Cloth, into a Glasse or other Vessel, this liquour is of it self a very fair red Colour, and is used to rule Books with red Lines, and is commonly called Red Inke.

If you take Logwood and boil it in all respects as you did your Brasil, it will make a very curious Purple Colour.

How to grinde and temper Rosset.

TAKE Rosset and lay it on your grinding stone, and grinde it with a little Gum-water, so that it be very stiff, then when it is ground fine enough, take it & put it into a Galley Pot, & when you would use it, temper it with Brasil water, this Colour differeth not much from the Colour of Lake, but it is much cheaper, and will not keep colour half so long.

How to grinde and temper Blew or Green Bice.

TAKE Blew or Green Bice, and grinde it upon your stone with fair water, then take it and put it into a Galley pot, and fill the pot with fair water, and so let it rest two or three hours, often stirring it about with a stick. then let it stand till the Bice be all settled to the bottoome, then poure away the water from the Bice, and put in more clean water, letting it stand, and stirring it as before, then poure that water away, and put in more clean water, thus continuing 4 or 5 times, then lastly, when you would use it temper it up with Gum-water.

How to grinde Indico.

TAKE Indico, and grinde it with Gum-water upon your stone very fine, then take it and put it into a pot or shell, and it is fit for

use, this Colour of it self is a very sad blew, but you may make it lighter at pleasure, by adding thereto some white Lead ground also with Gum-water.

How to temper Smalt.

TAKE fine Smalt, and put it into a Galley pot, then put thereto some Gum-water, and temper it up with a pencil, This Colour needeth no grinding, it being fine enough of it self.

How to grinde & temper Blue or Green Verditer.

TAKE Blue or Green Verditer, and grinde it with Gum-water on your stone, when it is fine enough, take and put it into a pot or shell for your use.

How to use Gum-boogd.

TAKE Gumboogd, and break it in small pieces, then put it into a clean pot, and put thereto clean water, letting it there lie till it be dissolved, this is a fine transparent Colour, and excellent good to wash withall.

How to use Yellow Berries.

TAKE yellow Berries, and bruise them a little in a Morter, then put them into a pot, and put thereto some Allom-water, letting them steep therein and in half an houres time the Allom-water will be a very curious transparent Colour, if the Colour be too faint you may help it by putting in more Berries, but the longer the Berries lie in steep the better the colour will be, you may (if you please) when the Colour is as you would have it strain the water from the Berries, and reserve it for your use, or you may use it without straining.

How to grinde and temper Orpiment.

THERE is two sorts of Orpiment, the one is a Light Yellow, and the other is an Orient or Marigold Colour commonly called Orange Tawny. Take of either of these sorts and grinde them upon your stone with Gum-water, keep them in pots or shells for your use.

How to use Verdigrease.

THE best Verdigrease is that which is dissolved, take therefore distilled Verdigrease, and steep it ten or twelve hours in good Muscadine, and it will be a very fine transparent Green Colour.

How to use Sap green.

Take Sap-green, and put it into a pot or shell, and put thereto white Wine Vineger, and a little bit of Allom, this will make an excellent Green for Trees, Hedges, &c. if at any time it grow too thick add more Vineger or Water, or rather half Water and half Vineger.

There are some other ordinary Colours, which will be very useful for you especially when you do to express Houses, Trees, Rivers, Mills, Mines, Gates, Cottages, Brooks, Pales, Barns, and such like; all which are to be ground and tempered with Gum-water, the names of which Colours are these following: White Lead, Lambé black, Umber, Spanish Brown; Almezum, and Bolcarmoniack: these Colours are all very cheap, and are all to be ground with Gum-water, and by mingling two of these or other Colours together, you may make almost what Colour you please of any Blew and Yellow mixed together make a Green, &c. of these last mentioned Colours, most of which are very sad Colours, they ought to be ground very fine, and good store of Gum-water used in the tempering of them.

CHAP. LIX.

How to find whether water may be conveyed from a Spring head, to any appointed place.

Here is an Instrument called a Water-level, for the performance hereof, the making whereof is sufficiently known. Now if it were required to know whether water may be conveyed in Pipes or Trenches from a Spring-head to any determinate place, observe the following directions.

Place your Water-level at some convenient distance from the Spring-head, in a right line towards the place to which the water is to be conveyed; as at 30, 40, 60, or 100 yards distant from the Spring-head. Then having in a readines two long straight poles (which you may call your station staves) divided into Feet, Inches, and parts of Inches from the bottom upwards: being thus provided, cause one (whom you may call your *first assistant*) to set up one of the said staves at the Spring-head, and require another (which you may call your *second assistant*) to erect the other staff beyond your Instrument at 30, 40, 60, or 100 yards forward, towards the place to which the water should be conveyed. These station staves being erected perpendicular, and your Water-level in the mid-way precisely horizontal, go to the end of the Level, and looking through the sights, cause your *first assistant* to move a leaf of paper up and down your station staff, till through the sights you see the very edge thereof, and then by some known signe or sound, intimate

to him that the paper is then in its true position, then let this *first assistant* note against what number of Feet, Inches, and parts of an Inch the edge of the paper resteth, which he must note down in a paper. Then your Water-level remaining immoveable, go to the other end thereof, and looking through the sights towards your other station staff, cause your *second assistant* to move a leaf of paper along the staff, till you see the very edge thereof through the sights, and then (by some known signe or sound) cause him to take notice what number of Feet, Inches, and parts of an Inch, are cut by the said paper, which will him also to keep in minde, or note in a paper as your *first assistant* did.

This done, require your *first assistant* to bring his station staff from the Spring head, and cause your *second assistant* to take that staff and carry it forward towards the place to which the water is to be conveyed, 30, 40, 60, or 100 yards, and there to erect it perpendicular as before, letting your *first assistant* stand at that staff where your *second assistant* before stood; then in the mid way between your two assistants, place your Water-level exactly horizontal, and looking through the sights thereof, cause your *first assistant* to move a paper up and down, and when you give him a signe to note what number of Feet, Inches, and parts of an Inch are cut by the paper, and note them down, then going to the other end of your Water-level, look through the sights, and cause your *second assistant* to move a paper along the Staff, and to note the Feet, Inches, and parts of an Inch as before.

Then cause your *first assistant* to bring away his station-staff, and cause your *second assistant* to take it and carry it 30, 40, 60, or 100 yards forwarder, towards the place to which the water is to be conveyed, and leaving your *first assistant* at the place where your *second assistant* last stood, place your Water-level again in the mid-way between your two Assistants; and looking through the sights as before, cause each of them to move a leaf of paper up and down their station staves, and note down in their several papers the number of Feet, Inches, and parts of an Inch cut, when you looked through the sights of your Water-level.

In this manner you must go along from the Spring head, to the place unto which you would have the water conveyed, and if there be never so many several stations, you must, in all of them, observe this manner of work precisely; so by comparing the notes of your two Assistants together you may easily know whether the water may be conveyed from the Spring-head to the desired place or not, though there be many Hills between.

Here note, that in your passage between the Spring head and the appointed place, from station to station, you must observe this order, otherwise great errour wil ensue, *viz.* that your *first assistant* must at every station, stand between the Spring head and your Water-level; and your *second assistant* must alwayes stand between your Water-level and the place to which the water is to be conveyed; thus by observing this order in your work

work you shal have no confusion, neither shal one of your Assistants take more pains then the other.

Having thus orderly proceeded from the Spring head to the place appointed, call both your Assistants together, and cause them to give in their notes of the observations at each station, and add them together severally: then if the note of the *second assistant* exceed (or be greater then) the note of the *first assistant*, take the lesser out of the greater, and the remainder will shew you how much the appointed place to which the water is to be brought is lower then the Spring head.

The first Assistants Note.

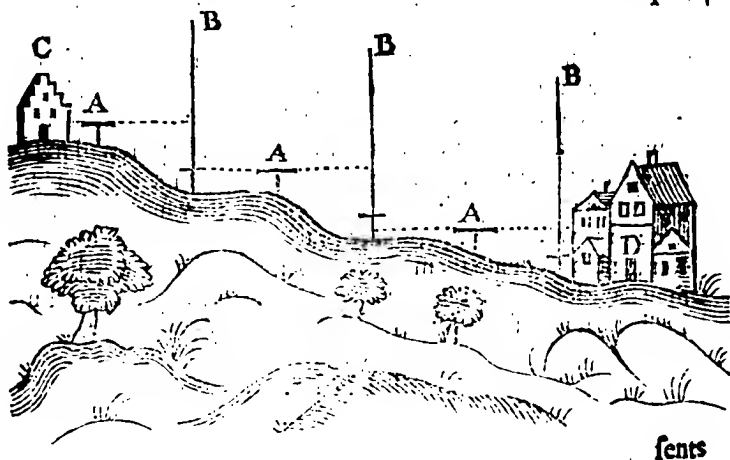
Station.	Feet	Inch	Parts.
1	15	3	$\frac{1}{2}$
2	2	1	$\frac{1}{4}$
3	1	6	0
Sum	18	10	$\frac{1}{4}$

The second Assistants Note.

Station	Feet	Inch	Parts
1	3	2	$\frac{3}{4}$
2	14	0	$\frac{1}{4}$
3	3	11	0
Sum	21	2	0

By this Table you may perceive that the notes of the *first assistant* collected at his several itations being added together, amounteth to 18 Feet, 10 Inches; and $\frac{1}{4}$ of an Inch: and the notes of your *second assistant* at his several itations being added together amounteth to 21 Feet and two Inches, so the number of the *first assistants* observations being taken from the number of the second, there will remain 2 Feet, 3 Inches and and $\frac{3}{4}$ of an Inch, & so much is the place to which the water is to be brought, lower then the Spring head, according to the straight Water-level, and therefore the water may easily be conveyed.

Having expressed as plainly as I can in words the manner of conveying of water from a Spring-head to any appointed place, it will not be amiss to insert a figure by the sight whereof you may plainly perceive how it is effected, in which figure note that A repre-



presents the Instrument or Water-level, and the station staves : C the Spring-head, and D the place to which the water is to be conveyed.

- Here note that when you have called your two Assistants together, and examined their several Notes, and added them together, if then you shall finde the summe of your *first assistants* Note to be greater then the sum of your *second assistants* Note, that then it is impossible to bring the water from that Spring-head to the intended place : but if the Sums of the Notes of your two Assistants do exactly agree ; there is then a possibility of effecting it, if the distance be but short, though with more charge and difficulty.
- Note 2, That the most approved Authours concerning his particular do aver, that at every miles end there ought to be allowed 4 $\frac{1}{2}$ Inches more then the straight Level for the current of the water.
- Note 3, If there be any Hill lying in the way between the Spring-head and the place to which the water is to be conveyed you must then cut a Trench by the side of the Hill in which you must lay your pipes equal with the straight Water-level, with the former allowance. And in this case there be a Valley you must then make a trunk of strong wood well under-prepped with strong pieces of timber, and well pitched or leaded, as is done in divers places between *Ware* and *London*.
- Note 4, That in conveying of water to an appointed place, it is not convenient to bring it from the Spring-head by the neereest distance or in a straight Line, but by a crooked or winding way ; and you ought also to lay the Pipes one up and another down, but this is to be observed but in some cases only, where the water will have too violent a current.

Thus I have finished my intended discourse of Surveying of land, in which I have studied rather to make every particular therein contained plain and perspicuous to the meanest capacity, then with too much brevity to obscure that which I chiefly aimed at, namely, to instruct the ignorant : I confess, I may be justly blamed by those who are Masters of the Art, or have a considerable knowledge thereof already, for using too many circumlocutions, but I answer, it was not written for their sakes, yet I hope it will not be rejected by them ; and although I do not attempt to teach such more then they know already, yet (possibly) they may herein find something worth their perusal & practice, or (at least) it may be a Remembrancer unto them to bring to minde what otherwise they may have forgotten. But ceasing to apologize any more for my Book, let it now speak for it self.

FINIS.

